

A contribution to the Dicyrtomidae (Collembola) of Hawaii

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Ten new species in three subgenera of *Dicyrtoma* are described from the Hawaiian Islands. Specimens were received from collections made on Hawaii, Maui, Kauai and Oahu. Species definitions are based on chaetotaxy of head, legs and the circumanal region. In addition, presence or absence of lateral spines (neosminthurid setae) on the parafurcular lobes may assist in grouping species within subgenera. Previous records of dicyrtomids from Hawaii include only one species, *Ptenothrix* (*Papirioides*) *dubia* (Folsom). The following new species are described: *Ptenothrix* (*Ptenothrix*) *hawaiiensis* sp.n., *Ptenothrix* (*Papirioides*) *kauaiensis* sp.n., *P. (Papirioides)* *serrata* sp.n., *Dicyrtoma* (*Calvatomina*) *sylvestralis* sp.n., *D. (Calvatomina)* *brevifibra* sp.n., *D. (Calvatomina)* *tesselata* sp.n., *D. (Calvatomina)* *longidigita* sp.n., *D. (Calvatomina)* *bellingeri* sp.n., *D. (Calvatomina)* *maestrus* sp.n., and *D. (Calvatomina)* *microdentata* sp.n.

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Introduction

The purpose of this report is to describe 10 new species of dicyrtomids from Hawaii. Specimens were accumulated from field samples and research holdings either collected or borrowed by Drs K. A. Christiansen and P. F. Bellinger as the basis of their forthcoming monograph on the collembolan fauna of Hawaii. The species disclosed here were sent to the author for examination and description.

The Hawaiian Collembola have not received much attention, although the island group has attracted large numbers of biologists. Carpenter (1904) was the first to publish on the collembolan fauna of the Hawaiian islands (Sandwich Islands). He described five species, none of which were dicyrtomids. Folsom (1932) made the next contribution to the faunal list by adding 22 new records. He described *Ptenothrix dubia* from a small collection (four specimens) considering it to be similar to, or “may be *Ptenothrix mirabilis* Denis (1929) . . . described from China”. Because Denis had only four specimens, of which two lacked the dorsal tubercle, the early status of *P. dubia*, in Folsom’s opinion (1932), remained in doubt. The most recent work is Zimmerman’s (1948) “Insects of Hawaii”; a rewrite of Folsom (1932), presented without species descriptions and following the higher categories presented by Wormersley (1939).

Modern work on the Dicyrtomidae began with Stach (1957). He recognized the need for comparative chaetotaxy studies to separate similar species. In addition he redefined the family, organized a key to genera and species, and presented a number of critical descriptions of European examples. Following his publication, a number of significant contributions were made by authors in the Pacific region. Uchida (1953, 1957a) proposed a dental setae formula for dicyrtomid species. Subsequently, a number of modifications of his system have come into use.

Murphy (1960) stated that presence or absence of lateral spines (neosminthurid setae) at the base of the

manubrium (parafurcular lobes) appears to be a valuable taxonomic feature. This characteristic and the lack of vertical cephalic spines permitted him to place *Dicyrtomina oryzae* Murphy, 1960 in the “*rufescens* group”. Hüther (1965, 1967) found the same characteristic for *Dicyrtomina rufescens* (Reuter) and *Dicyrtomina pseudorufescens* Hüther. Yosii & Lee (1963) devised a scheme for denoting the setae of the anogenital region of *Ptenothrix*, which Yosii (1969) later modified for use with *Dicyrtomina* and *Calvatomina*. Yosii & Ashraf (1965) used these characteristics and other setae of the head and body to clearly separate *Dicyrtoma* (*Dicyrtoma*) *pakistanica* Yosii & Ashraf from *Ptenothrix* and *Dicyrtomina*.

Folsom (1924) described a new species and genus, *Papirioides jacobsoni* from Sumatra. Its general morphology was close to *Ptenothrix*, except it exhibited a large abdominal, median dorsal, club-like structure. This characteristic seemed sufficiently unique for generic recognition. Uchida (1957b) placed his species *Papirioides uenoi* in this genus for the same reasons. Stach (1965), agreeing with this characteristic, described *Papirioides aequituberculata* from North Korea. He commented that Folsom’s (1932) *dubia* and Denis’ (1929) *mirabilis* belonged in *Papirioides*.

Uchida (1944) described *Dicyrtomina trukana* from Micronesia, a species with a dorsal abdominal tubercle and 5 segmented antenna. He also compared three genera of sminthurids exhibiting tubercles with *Dicyrtomina*. Stach (1957) placed *trukana* in the subgenus *Pseudodicyrtomina* based on the 5 segmented antenna, however, the genus otherwise appeared to fit well within *Calvatomina*. Betsch (1980) followed Yosii (1969) by placing *Dicyrtomina verrucosa* Handschin, *Dicyrtomina bombyensis* Yosii and *D. trukana* in the genus *Calvatomina* under the “*Pseudodicyrtomina* group”. He noted that only *trukana* appeared to exhibit 5 antennal segments. All three species showed a posterior abdominal tubercle with strong spines. Yosii (1969) separated *Calvatomina*,

Table I. New species from Hawaii described in this paper

Family Dicyrtomidae
Tribe Ptenothricini
<i>Ptenothrix</i> (<i>Ptenothrix</i>) <i>hawaiiensis</i> , sp.n.
<i>Ptenothrix</i> (<i>Papirioides</i>) <i>kauaiensis</i> , sp.n.
<i>Ptenothrix</i> (<i>Papirioides</i>) <i>serrata</i> , sp.n.
Tribe Dicyrtomini
“ <i>formosana</i> group”
<i>Dicyrtoma</i> (<i>Calvatomina</i>) <i>sylvestrilis</i> , sp.n.
<i>Dicyrtoma</i> (<i>Calvatomina</i>) <i>brevifibra</i> , sp.n.
<i>Dicyrtoma</i> (<i>Calvatomina</i>) <i>tesselata</i> , sp.n.
<i>Dicyrtoma</i> (<i>Calvatomina</i>) <i>longidigita</i> , sp.n.
<i>Dicyrtoma</i> (<i>Calvatomina</i>) <i>bellingeri</i> , sp.n.
“ <i>rufescens</i> group”
<i>Dicyrtoma</i> (<i>Calvatomina</i>) <i>madestris</i> , sp.n.
<i>Dicyrtoma</i> (<i>Calvatomina</i>) <i>microdentata</i> , sp.n.

“*Pseudodicyrtomina* group” from the “*rufescens* group” and “*formosana* group” on the basis of the ventral dental setae; 4–2–1–1–1 . . . 1 for the former and 4–2–1–1 . . . 1 for the latter two groups. Betsch (1980) said that the “*Pseudodicyrtomina* group” would seem to be equivalent to *Papirioides* with respect to *Ptenothrix*. So far, the collections from Hawaii have not produced any specimens from the “*Pseudodicyrtomina* group”.

Currently we rely upon three modern works to position higher categories within Dicyrtomidae. First, Richards (1968) separated *Bothriovulsus*, *Papirioides* and *Ptenothrix* into the tribe Ptenothricini on the basis of bothriothrix D being present and antennal segments III and IV being subannulated. He placed *Dicyrtoma* and *Dicyrtomina* in the tribe Dicyrtomini based on lack of bothriothrix D and subannulations on antennal segment IV. His opinions were predicated on thesis research concluded 12 years earlier (Richards, 1956). Very little editing between thesis publication and 1968 had taken place. It is, therefore, not surprising that the papers by Yosii (1960, 1966, 1969), Yosii & Ashraf (1965) and Yosii & Lee (1963) were not included in his final analysis. While he cited Stach (1957) for elevating Dicyrtomidae to family level, he did not mention the genera *Pseudodicyrtomina* (Stach, 1957) or *Gibberathrix* (Uchida, 1952a). In spite of these omissions, his analysis of genera was strongly presented. Many critical morphological characteristics commonly used today are a direct result of his research.

Betsch (1980) presented an overview of the Dicyrtomidae. He combined the work of Richards (1968), Yosii (1960, 1966, 1969), Yosii & Lee (1963) and Yosii & Ashraf (1965) to produce analytical reviews of each genus and an updated version of Richards’ (1968) taxonomic key to genera. Betsch believed that *Calvatomina* and other subgenera should be elevated to generic status. He pointed out that *Calvatomina* formed a homogeneous Holotropical group, while *Dicyrtomina* was Holarctic in distribution.

Christiansen & Bellinger (1981) did not include the work of Betsch (1980) in their treatment of the North American collembolan fauna. As a result they took a conservative view of the family. They preferred to use a hybridization of Richards (1968) and Gisin (1960) which reduced *Bothriovulsus*, *Dicyrtomina* and *Ptenothrix* to subgenera under *Dicyrtoma*. Some exception must be

Table II. Circumanal and parafurcular seta formulae where (+) = blunt spine, (–) = seta-like, (±) = sharp spine and (0) = seta absent; 3/2 = 3 spines, 2 seta-like, 5/0 = 5 spines and 0/5 = spines absent

Species	Anogenital setae										Parafurcular setae
	M	M'	N	N'	A ₀	T	H	G	L		
<i>hawaiiensis</i>	+	+	+	0	+	+	+	+	+	0/5	
<i>kauaiensis</i>	+	+	+	0	—	+	+	—	—	0/5	
<i>serrata</i>	+	+	+	0	+	—	±	—	+	0/5	
<i>sylvestratilis</i>	+	+	+	+	—	—	+	—	+	5/0	
<i>brevifibra</i>	+	+	+	+	—	0	+	±	+	3/2	
<i>tesselata</i>	+	+	+	—	—	0	+	+	+	3/2	
<i>longidigita</i>	+	+	+	±	—	—	+	—	+	3/2	
<i>bellingeri</i>	+	+	+	+	—	—	+	±	+	3/2	
<i>madestris</i>	+	—	+	+	+	—	+	0	+	5/0	
<i>microdentata</i>	+	—	+	—	+	—	+	—	+	5/0	

taken with their interpretation. Presence or absence of bothriothrix A and D is a strong characteristic and along with the number and type of spines on the metatibia can be used to clearly separate Ptenothricini from Dicyrtomini. In addition, at the generic or subgeneric level, the following characteristics used by them for North American species cannot be applied successfully to Pacific species: antennal subannulation, number of unpaired facial setae [extreme variation between *Dicyrtoma*, *Dicyrtomina*, *Calvatomina* and *Ptenothrix*, (Snider, 1985a,b)], or claw structure.

Even though a strong argument can be presented for separation of subgenera into genera as presented by Betsch (1980), a more conservative system incorporating his ideas and Christiansen & Bellinger (1981) and Yosii (1969) is used here. Ten new species are described from Hawaii. Their separation from each other and from species described earlier from the Pacific-tropical area relies heavily on anogenital chaetotaxy.

Table I lists the new species and, where appropriate, the “group” to which they belong. Types are deposited in the Bishop Museum, Honolulu, Hawaii. In addition, Table II summarizes the anogenital chaetotaxy used for species division.

Account of species

Ptenothrix (*Ptenothrix*) *hawaiiensis* sp.n. (Figs 1–31)

Material examined. Holotype (♀) and paratype on slides. Hawaii, Hawaii County, Lava Tree State Park, beating vegetation, 20 January 1982, K. A. Christiansen. Maui, Maui County, Koolau Gap, Haleakala Crater, 7000 feet elev., moss on rock, 7 February 1964, Tsuda.

Description

Color. (Description based on specimens mounted on slides in Hoyer’s medium.) Background opaque to white with blue pigment distributed in the following patterns. Antenna uniformly blue. Vertex of head with blue maculae, dark blue-black patch between ocelli; frons and gena with irregular blue mosaics. Great abdomen with blue mosaics forming irregular lateral patterns. Legs with blue banding at intervals. Furcula light blue. Lesser abdomen blue with flecks of blue-black (Fig. 1).



Fig. 1. *Ptenothrix (Ptenothrix) hawaiiensis* sp.n., habitus. Total length up to 2 mm.

Morphology. Eyes 8 + 8; ocellus H 1/2 diameter of others (Fig. 2). Mean antennal ratio 1:4.2:5.5:1; ANT I with 5 dorsal and 2 ventral setae (Fig. 3); ANT II with 2 dorsal and 1 ventral cup sensilla; ANT III divided into 8 distal subsegments, armed with cup sensilla, subapical sensilla exposed, lying in shallow depressions; ANT IV divided into 4 subsegments. Outer maxillary lobe consists of simple palp and 1 sublobal hair (Fig. 4). Labrum with setal pattern 6/5, 3, 4 (Fig. 5). Dorsal setae of head spine-like (Fig. 6); 2 unpaired facial setae (Fig. 7) and 1 + 1 oval organs on lower frons.

Foreleg. Coxa, trochanter and femur not clearly seen; tibiotarsus with 4 cup sensilla and 1 oval organ on anterior surface (Fig. 8), 1 oval organ on posterior surface (Fig. 9); pretarsus with anterior and posterior setulae; unguis lacks tunica, with 2 strong inner teeth; unguiculus with strong corner tooth, apical filament reaching beyond tip of unguis, knobbed (Fig. 10).

Mesoleg. Coxa with 3 anterior setae and 1 "courte épine" (Fig. 11); trochanter with 4 anterior and 1 posterior setae and oval organ (Fig. 12); femur with 8 anterior and 5 posterior setae, 1 posterior setula and oval organ (Fig. 13); tibiotarsus with 4 cup sensilla and 1 oval organ on anterior surface (Fig. 14), 1 "courte épine" on posterior surface (Fig. 15); pretarsus with anterior and posterior setulae; unguis lacks tunica, with 2 strong inner teeth; unguiculus with strong corner tooth, and sometimes a second accessory tooth, apical filament knobbed, reaching beyond tip of unguiculus (Fig. 16).

Metaleg. Coxa with 4 anterior setae and 1 "courte épine" (Fig. 17); trochanter with 5 anterior and 1 posterior setae (Fig. 18); femur with 9 anterior and 3 posterior setae and oval organ (Fig. 19); tibiotarsus with 5 cup sensilla and 1 "courte épine" on anterior surface (Fig. 20), 1 "courte épine" and 2 differentiated setae on posterior surface (Fig. 21); pretarsus with anterior and posterior setulae; unguis lacks tunica, with 2 strong inner teeth; unguiculus with strong corner tooth, and sometimes with second accessory tooth, apical filament knobbed, reaching beyond tip of unguis (Fig. 22).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae (Fig. 23), sacs warty. Corpus of tenaculum with 4 setulae, ramus with 3 teeth and basal horn (Fig. 24). Manubrium with 7 + 7 dorsal setae (Fig. 25). Dens with 3, 2, 1, . . . 1 Ve setae (Fig. 26), dorsal setae basally

serrate, E setae ratio $E_1/E_2 = 0.75-0.95$ and $E_3/E_2 = 1.80-1.85$ (Fig. 27). Mucro with inner and outer teeth (Fig. 28). Parafurcular lobes with normal, smooth setae (Fig. 29). Circumanal setae M, M' and N spine-like and smooth, seta sa normal; other setae follow pattern

M	N	T	H	G	A ₀	sa
3	2	+	+	+	+	-

other upper valve setae finely serrate; female subanal appendage slightly curving, acuminate (Fig. 30). Bothriothrix D present. Anterior body setae (AA-EE) spine-like, smooth (Fig. 31), posterior dorsal setae short, dagger-like becoming longer laterally. Length up to 2 mm.

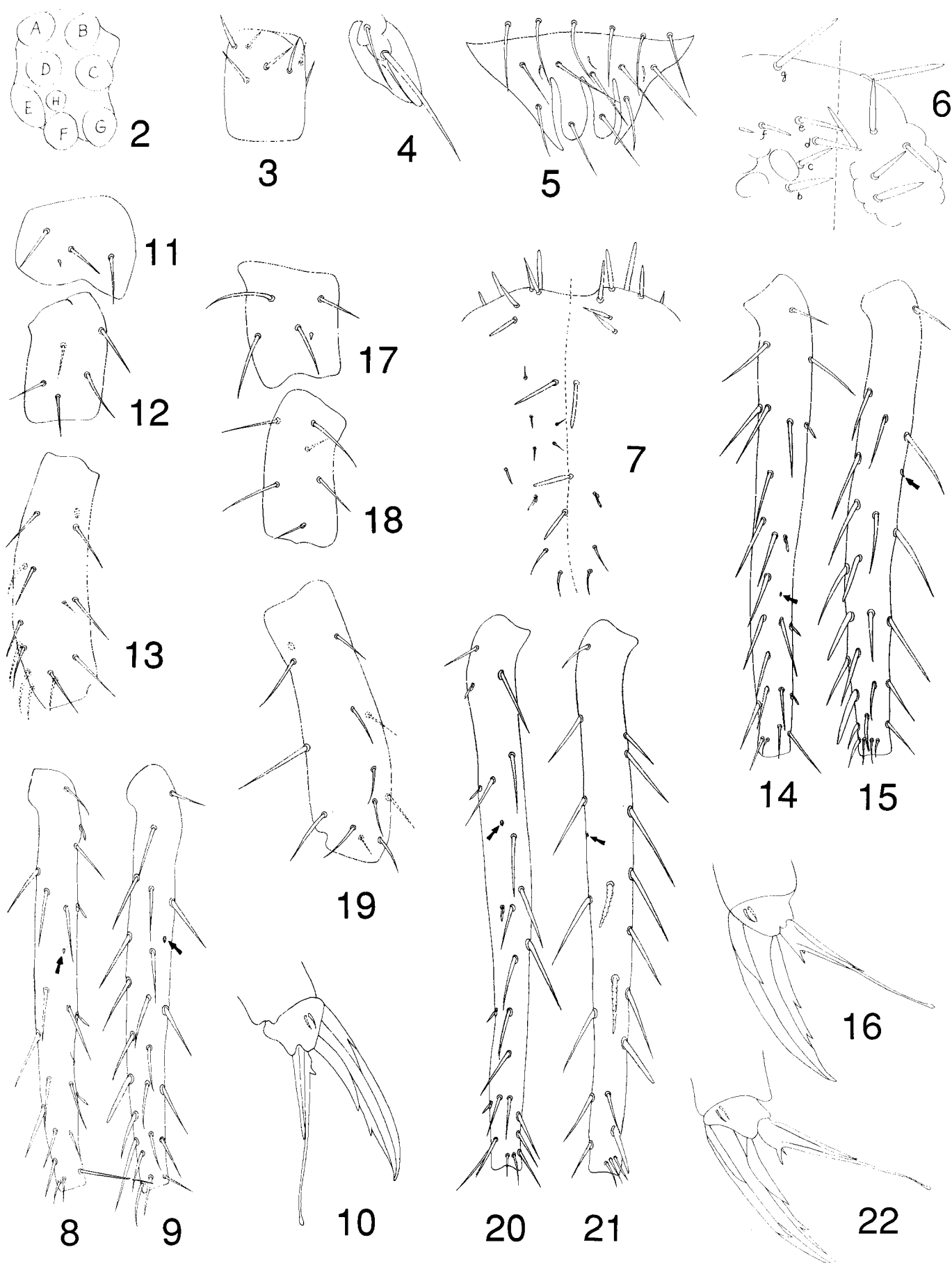
Diagnosis. *Ptenothrix (Ptenothrix) hawaiiensis* sp.n. most closely resembles *Ptenothrix (Ptenothrix) ciliophora* (Yosii & Lee, 1963) and *Ptenothrix (Ptenothrix) saxatilis* (Yosii & Lee, 1963), both endemic to Korea. Besides having facial setae 1-1-2-2-1-1, their labral setal formula is unique: 6/5, 3, 4. However, *ciliophora* has all median facial setae of the same diameter, while *saxatilis* shares the same thick type seta 1-1 followed by 2-2-1-1 as found in *hawaiiensis*. They all share finely serrate setae on the upper anal valve. Color pattern will easily separate these species. Another species, *Ptenothrix (Ptenothrix) gracillicornis* (Schaffer) has 1-1-2-2-1-1 facial setae. Further, if the illustration given by Yosii (1969) is re-examined, his formula 6/3, 5, 4 may be interpreted as 6/5, 3, 4 which would place this species close to *hawaiiensis*. The species can be separated on the basis of anal N setae, *gracillicornis* exhibits a setaceous rather than blunt spine-like type. It is clear that *hawaiiensis* can be classified between the "southern" and "Holarctic" groups of *Ptenothrix* suggested by Yosii (1969). He utilized 1-1 blunt facial setae and relative lengths of circumanal setae. His system allows comparison with *Ptenothrix (Ptenothrix) brasiliensis* (Delamare & Massoud), 1963 and *Ptenothrix (Ptenothrix) argentina* (Delamare & Massoud), 1963 based on the length of sa and sa'; *hawaiiensis* is comparable. Cephalic, tibial and labral setae patterns will separate the species. Within the Hawaiian species complex, superficial comparison to *Ptenothrix (Papiroides) kauaiensis* sp.n. will distinguish it from that species by color pattern, facial spines, labral setae, lack of hump, and circumanal setal pattern.

Ptenothrix (Papiroides) kauaiensis sp.n. (Figs 32-65)

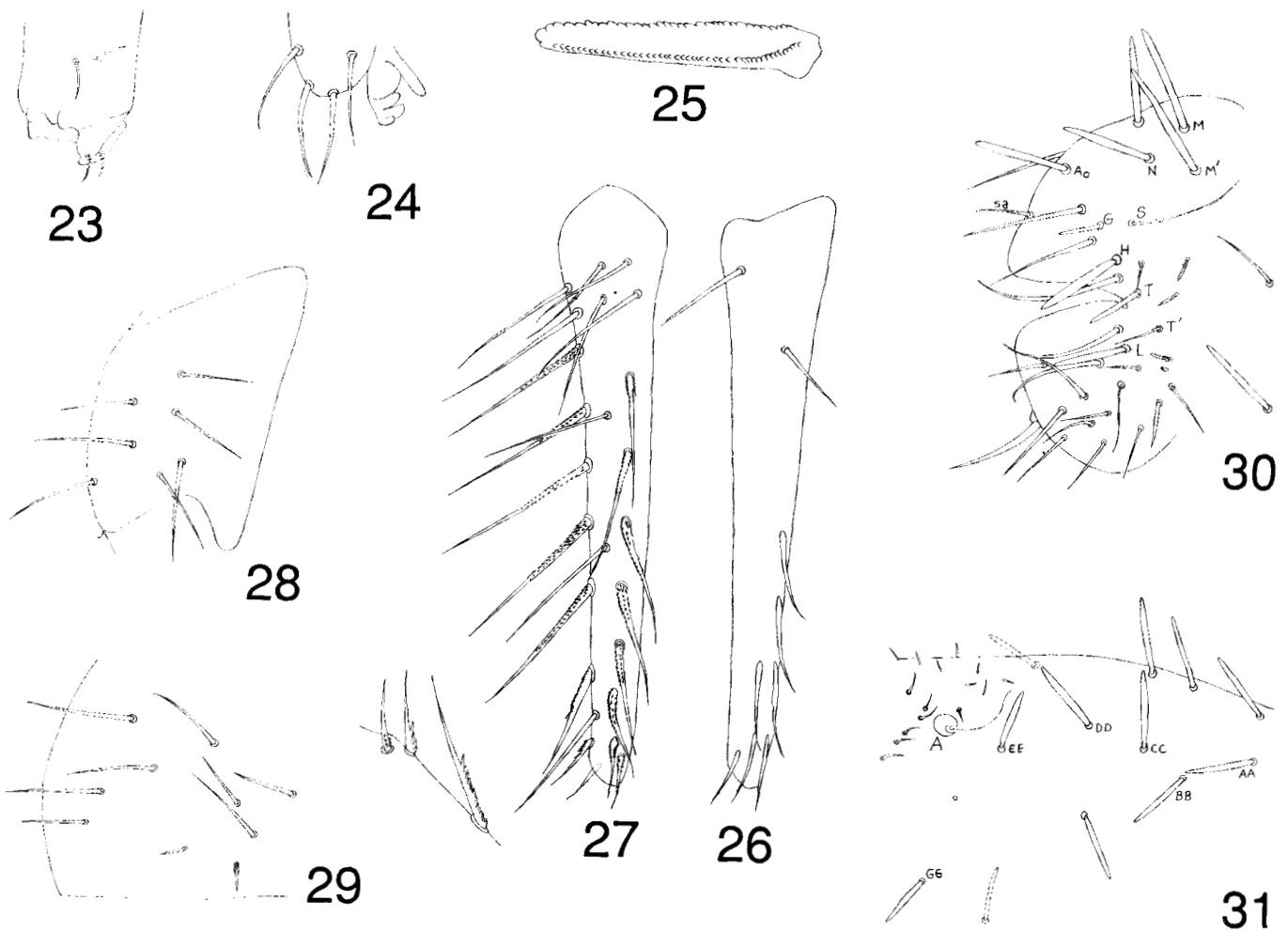
Material examined. Holotype (♀) and 5 paratypes on slides. Collection data: Hawaii, Kauai County, Wailua River crossing, sweeping near paved road to Experiment Station, 18 January 1967, P. F. Bellingher.

Description

Color. The specimens examined are all on slides; their color pattern is poorly preserved. However, Dr Christian-sen made notes on the pattern before mounting at least one example. Yellow with purple pigment limited to middorsal line on posterior portion of great abdomen, with small scattered patches elsewhere on head and body.



Figs 2-22. *Ptenothrix (Ptenothrix) hawaiiensis* sp.n.—2. Left eyepatch.—3. Antennal segment I.—4. Outer maxillary lobe.—5. Labrum.—6. Dorsal setae of head.—7. Median facial setae.—8. Foretibiotsarsus, anterior surface.—9. Foretibiotsarsus, posterior surface.—10. Foreclaw.—11. Mesocoxa.—12. Mesotrochanter.—13. Mesofemur.—14. Mesotibiotarsus, anterior surface.—15. Mesotibiotarsus, posterior surface.—16. Mesoclau.—17. Metacoxa.—18. Metatrochanter.—19. Metafemur.—20. Metatibiotarsus, anterior surface.—21. Metatibiotarsus, posterior surface.—22. Metaclaw.



Figs 23–31. *Ptenothrix (Ptenothrix) hawaiiensis* sp.n.—23. Collophore, lateral view.—24. Corpus of retinaculum.—25. Mucro.—26. Dens, ventral surface.—27. Dens, dorsal surface and detail.—28. Manubrium, dorsal surface.—29. Parafurcular setae.—30. Anal papilla.—31. Anterior body setae and bothriotrix A.

Antenna uniformly purple. Legs banded with purple (Fig. 32).

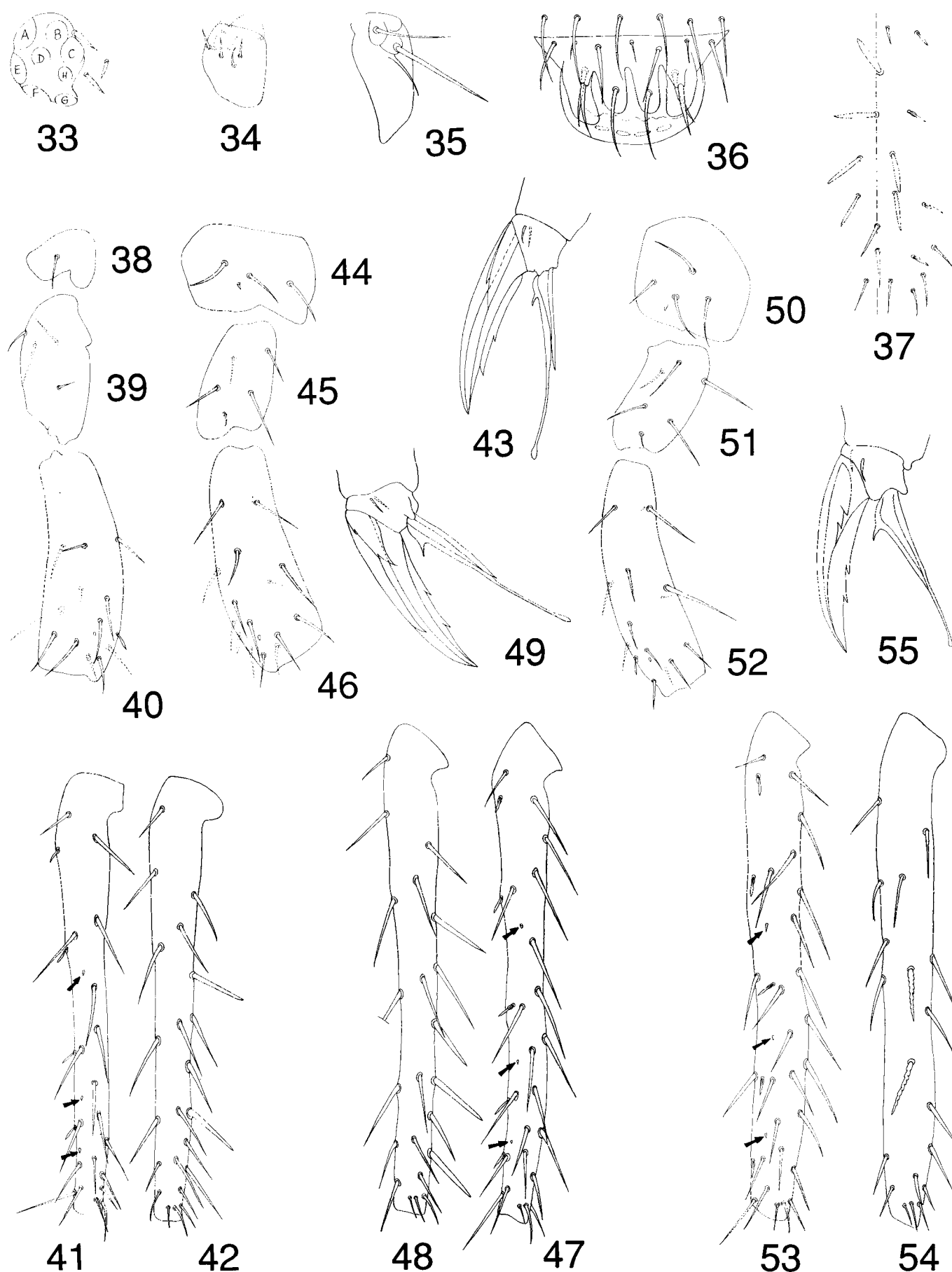
Morphology. Eyes 8 + 8; ocelli D and H subequal and 1/2 diameter of others (Fig. 33). Mean antennal ratio 4:19:24:6; ANT I with 5 dorsal and 2 ventral setae (Fig. 34); ANT II with 2 dorsal and 1 ventral cup sensilla; ANT III divided into 7 subsegments, armed with cup sensilla, subapical sensilla exposed, lying in shallow depressions; ANT IV divided into 5 subsegments. Outer maxillary lobe consists of simple palp and sublobal hair (Fig. 35). Labrum with setal pattern 6/7, 2, 4 (Fig. 36). Dorsal setae of head short, spine-like, a-seta reduced; facial setae not truly blunt, arranged as 1–1–2–2–1–1, lower frons with 1 + 1 oval organ (Fig. 37).

Foreleg. Coxa with 1 seta, no oval organ (Fig. 38); trochanter 2 anterior and 2 posterior setae (Fig. 39); femur with basal posterior and distal anterior oval organs, cup sensillum on outer margin (Fig. 40); tibiotarsus with 4 cup sensilla and 3 oval organs (almost “courtes épines”) on anterior surface (Fig. 41), oval organ lacking on posterior surface (Fig. 42); pretarsus with anterior and posterior setulae; unguis lacks tunica, with basal lateral teeth, 2 inner teeth, well developed; unguiculus with corner tooth, subapical filament reaching beyond tip of unguis, knobbed (Fig. 43).

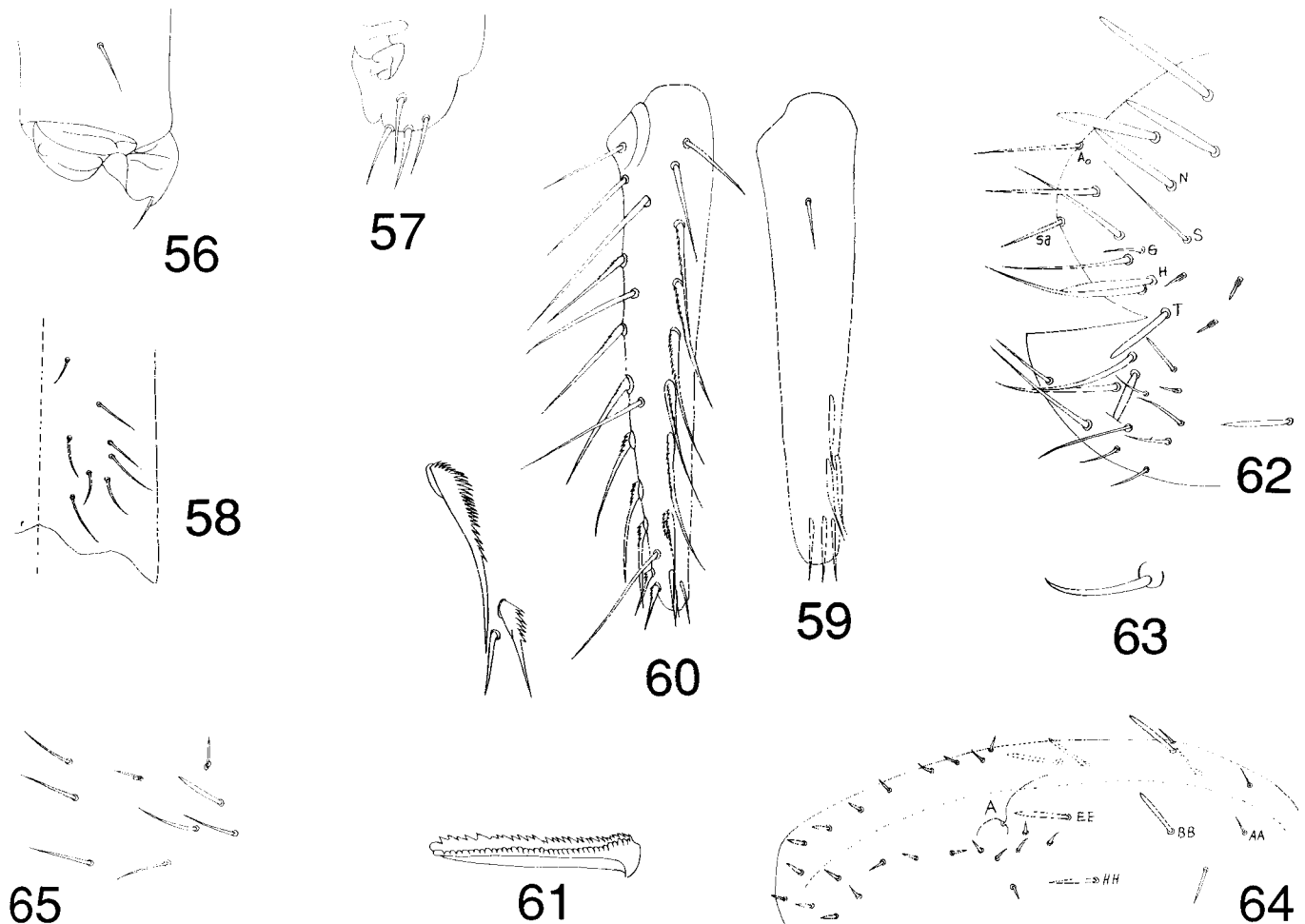
Mesoleg. Coxa with 3 anterior setae and 1 “courte épine” (Fig. 44); trochanter with 4 anterior and 1 posterior setae, D₂ seta much reduced (Fig. 45); femur with anterior and posterior “courtes épines”, cup sensillum on outer margin (Fig. 46); tibiotarsus with 5 cup sensilla and 3 “courtes épines” on anterior surface (Fig. 47), no



Fig. 32. *Ptenothrix (Papirioides) kauaiensis* sp.n., habitus. Total length of entire animal up to 1.5 mm.



Figs 33–55. *Ptenothrix (Papiroides) kauaiensis* sp.n.—33. Left eyepatch.—34. Antennal segment I.—35. Outer maxillary lobe.—36. Labrum.—37. Median facial setae.—38. Forecoxa.—39. Foretrochanter.—40. Forefemur.—41. Foretibiotsarsus, anterior surface.—42. Foretibiotsarsus, posterior surface.—43. Foreclaw.—44. Mesocoxa.—45. Mesotrochanter.—46. Mesofemur.—47. Mesotibiotsarsus, anterior surface.—48. Mesotibiotsarsus, posterior surface.—49. Mesoclaw.—50. Metacoxa.—51. Metatrochanter.—52. Metafemur.—53. Metatibiotsarsus, anterior surface.—54. Metatibiotsarsus, posterior surface.—55. Metaclaw.



Figs 56–65. *Ptenothrix (Papiroides) kauaiensis* sp.n.—56. Collophore, lateral view.—57. Corpus of retinaculum.—58. Manubrium, dorsal surface.—59. Dens, ventral surface.—60. Dens, dorsal surface and detail.—61. Mucro.—62. Anal papilla, female.—63. Female subanal appendage.—64. Dorsal chaetotaxy of abdomen.—65. Parafurcular setae.

“courtes épines” on posterior surface (Fig. 48); pretarsus with anterior and posterior setulae; unguis similar to foreclaw, unguiculus with subapical filament reaching well beyond tip of unguis, knobbed (Fig. 49).

Metaleg. Coxa with 4 anterior setae and 1 “courte épine” (Fig. 50); trochanter with 5 anterior and 1 posterior setae, D₂ seta reduced (Fig. 51); femur with anterior and posterior “courtes épines” and outer cup sensilla (Fig. 52); tibiotarsus with 5 cup sensilla and 3 “courtes épines” on anterior surface (Fig. 53), posterior surface with 2 heavily serrate differentiated setae (Fig. 54); pretarsus with anterior and posterior setulae; unguis with basal lateral teeth, 2 inner teeth; unguiculus with strong corner tooth, subapical filament reaching tip of unguiculus, knobbed (Fig. 55).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae (Fig. 56), sacs warty. Corpus of tenaculum with 4 setulae, ramus with 3 teeth and basal horn (Fig. 57). Manubrium with 8 + 8 dorsal setae (Fig. 58). Dens with 3–2–1 . . . 1 Ve setae (Fig. 59), dorsal E and L setae serrate (Fig. 60), $E_1/E_2 = 0.70\text{--}0.90$ and $E_2/E_3 = 2.00\text{--}2.80$. Mucro with inner and outer teeth, outer file irregular and conical, inner even and rounded (Fig. 61). Circumanal setae M, M', and N spine-like and smooth, seta sa normal; other setae follow pattern (Fig. 62)

M	N	T	H	G	A ₀	sa
3	2	+	+	—	—	—

Female subanal appendage acuminate, curved (Fig. 63). Bothriothrix D present. Trunk setae AA and CC small, setaceous; BB, EE, GG, HH spine-like. Dorsal projection not well defined (Fig. 64). Parafurcular setae setiform, except 1 spine-like anterior example (Fig. 65). Length up to 1.5 mm.

Diagnosis. *Ptenothrix (Papiroides) kauaiensis* sp.n. appears to stand alone in the subgenus by having the unguicular subapical filament knobbed on all legs. Further, the female subanal appendage is acuminate and curving; other species have short blunt setae. Among the Hawaiian representatives of the genus, the spine-like trunk macrochaetae, unguicular filaments and subanal appendages will separate *kauaiensis* from all others. Until more material becomes available, placement in *Papiroides* sp. must remain in doubt. The low, poorly defined hump and strong *Ptenothrix* sp. characteristics seem to position this species nearer that subgenus.

Ptenothrix (Papiroides) serrata sp.n. (Figs 66–100)

Material examined. Holotype (♀) and 5 paratypes on slide; Hawaii, Honolulu County, Oahu, Mt. Tantalus, 1000 feet elev., pan trap, November 1966, J. Vockeroth. Additional paratypes (all on slides); Maui County, Maui, Haleakala Crater, Koalua Gap, 7000 feet elev., moss on rock, 7 February 1964, Tsuda, collector, 6 specimens on slide 1, 2 specimens on slide 2; Maui, Iao Valley State Park, approximately 1

mile from "needle", scrub forest and ferns and grass, under bark of fallen trees and stones. 3 February 1982, K. A. Christiansen, 1 specimen; Honolulu County, Oahu, Waimea Arboretum, 150 feet elev., Hawaiian domesticated plant section, on decorative lava rock in pools, 27 February 1982, K. A. Christiansen.

Description

Color. (Description based on specimens mounted on slides in Hoyer's medium.) Background yellow; antenna purple-blue except distal and basal quarters of ANT II, which are light; band of purple on lower frons, with irregular mosaics concentrated on gena; macula of blue between eyepatches, otherwise light. Body irregularly mottled, with faint wash of blue, middorsal line on anterior half, lower anal valves bluish, upper valve distally blue. Legs banded. Manubrium-dens purple-blue, becoming darker distally; mucro blue (Fig. 66).

Morphology. Eyes 8 + 8; ocellus D smaller than others (Fig. 67). Mean antenna ratio 1:4.5:5:1; ANT I with 5 dorsal and 2 ventral setae (Fig. 68); ANT II with 1 dorsal and 2 ventral cup sensilla; ANT III divided into 7 distal subsegments, armed with cup sensilla, subapical sensilla exposed, lying in shallow depressions; ANT IV divided into 5 subsegments. Outer maxillary lobe consists of simple palp and 1 sublobal hair (Fig. 69). Labrum with setal pattern 6/7, 2, 4 (Fig. 70). Dorsal setae of head short, spine-like (Fig. 71); 5–7 unpaired facial setae (Fig. 72) 1 + 1 "courtes épines" and 1 + 1 oval organs on lower frons.

Foreleg. Coxa with 1 anterior seta (Fig. 73); trochanter with 2 anterior and 2 posterior setae (Fig. 74); femur with basal posterior and distal anterior oval organs (anterior qualifies as "courte épine"), cup sensillum on outer margin (Fig. 75); tibiotarsus with 4 cup sensilla and 1 "courte épine" on anterior surface (Fig. 76), oval organ lacking on posterior surface (Fig. 77); pretarsus with anterior and posterior setulae; unguis lacks tunica, with basal lateral teeth, 2 inner teeth; unguiculus with corner tooth, subapical filament just reaching beyond tip of unguis (Fig. 78).

Mesoleg. Coxa with 3 anterior setae and 1 "courte épine" (Fig. 79); trochanter with 4 anterior and 1 posterior setae, D₂ seta normal (Fig. 80); femur with basal posterior oval organ and distal anterior "courte épine",

cup sensilla on outer margin (Fig. 81); tibiotarsus with 5 cup sensilla on outer margin and 3 "courtes épines" on anterior surface (Fig. 82), posterior surface with 1 cup sensillum and no "courte épine" (Fig. 83); pretarsus with inner and outer setulae; unguis lacking tunica, with basal lateral teeth and 2 well-developed inner teeth; unguiculus with corner tooth, subapical filament reaching tip of unguis (Fig. 84).

Metaleg. Coxa with 4 anterior setae and 1 "courte épine" (Fig. 85); trochanter with 5 anterior and 1 posterior setae, D₂ normal (Fig. 86); femur with basal posterior oval organ and anterior distal "courte épine" and outer cup sensilla (Fig. 87); tibiotarsus with 5 cup sensilla and 3 "courtes épines" on anterior surface (Fig. 88), posterior surface with 2 heavily serrate differential setae (Fig. 89); pretarsus with anterior and posterior setulae; unguis with basal lateral teeth, 2 outer teeth, and 2 well-developed inner teeth; unguiculus with corner tooth, lamella slightly more expanded than on foreclaw or mesoclaw, subapical filament reaching tip of unguis (Fig. 90).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae (Fig. 91), sacs warty. Corpus of tenaculum with 5–6 setulae, ramus with 3 teeth and basal horn (Fig. 92). Manubrium with 8 + 8 dorsal setae (Fig. 93). Dens with 3, 2, 1, 1 . . . 1 Ve setae, dorsal E and L setae serrate (Fig. 94), $E_1/E_2 = 1.50\text{--}2.35$ and $E_3/E_2 = 2.60\text{--}3.40$ (Fig. 95). Mucro with numerous fine inner and outer teeth (Fig. 96). Circumanal setae M, M' and N spine-like and smooth, seta sa normal; other setae follow pattern

M	N	T	H	G	A ₀	sa
3	2	—	±	—	+	—

(Fig. 97). Female subanal appendage straight, short, blunt (Fig. 98). Bothriothrix D present. Trunk setae, large, strong, only DD spine-like. Dorsal projection well defined, low (Fig. 99). Parafurcular setae setiform (Fig. 100). Length up to 2.2 mm.

Diagnosis. *Ptenothrix* (*Papirioides*) *serrata* sp.n. unlike *kauaiensis*, lacks knobbed subapical filaments on the unguiculi and has a greater number of unpaired facial setae. *Ptenothrix* (*Papirioides*) *dubia* (Folsom, 1932) is easily separated from *serrata* on the basis of color pattern, anal setae and prominent hump. Further, *dubia* has a 1–1–1–2–1–1 facial setal formula, while *serrata* has 1–1–1–2–1–1. Another difference is found in the setae of ANT I; *dubia* has 4 spine-like dorsal setae and 2 posterior, *serrata* has 5 dorsal, normal setae. The only other species that superficially resembles *serrata* is *Ptenothrix* (*Papirioides*) *mirabilis* (Denis, 1929) from China. That species has individuals that exhibit both the presence and absence of dorsal humps. Furthermore, the dorsal setae of the dens lack serrations in *mirabilis*.

Dicyrtoma (*Calvatomina*) *madestris* sp.n. (Figs 101–134)

Material examined. Holotype (♀) and 37 paratypes in ethanol: Hawaii, Kauai county, Kauai, glade by Wailua River, above falls, damp grass, 16 January 1967, 5 additional paratypes on slide from same location, 4 specimens on slide and 18 in ethanol collected from sticks on ground; Alakai Swamp Trail, forest moss on logs, 17 January 1967;

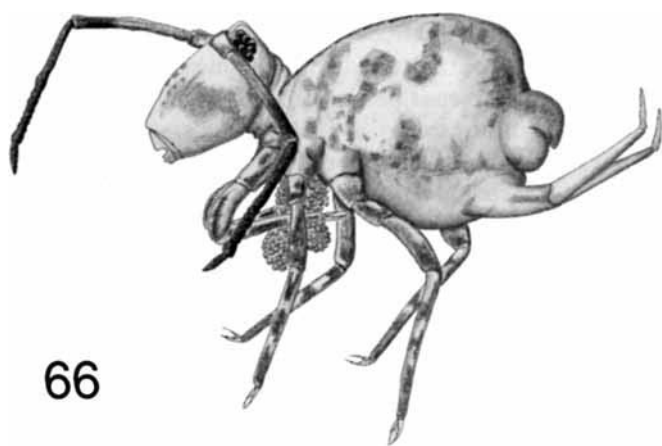
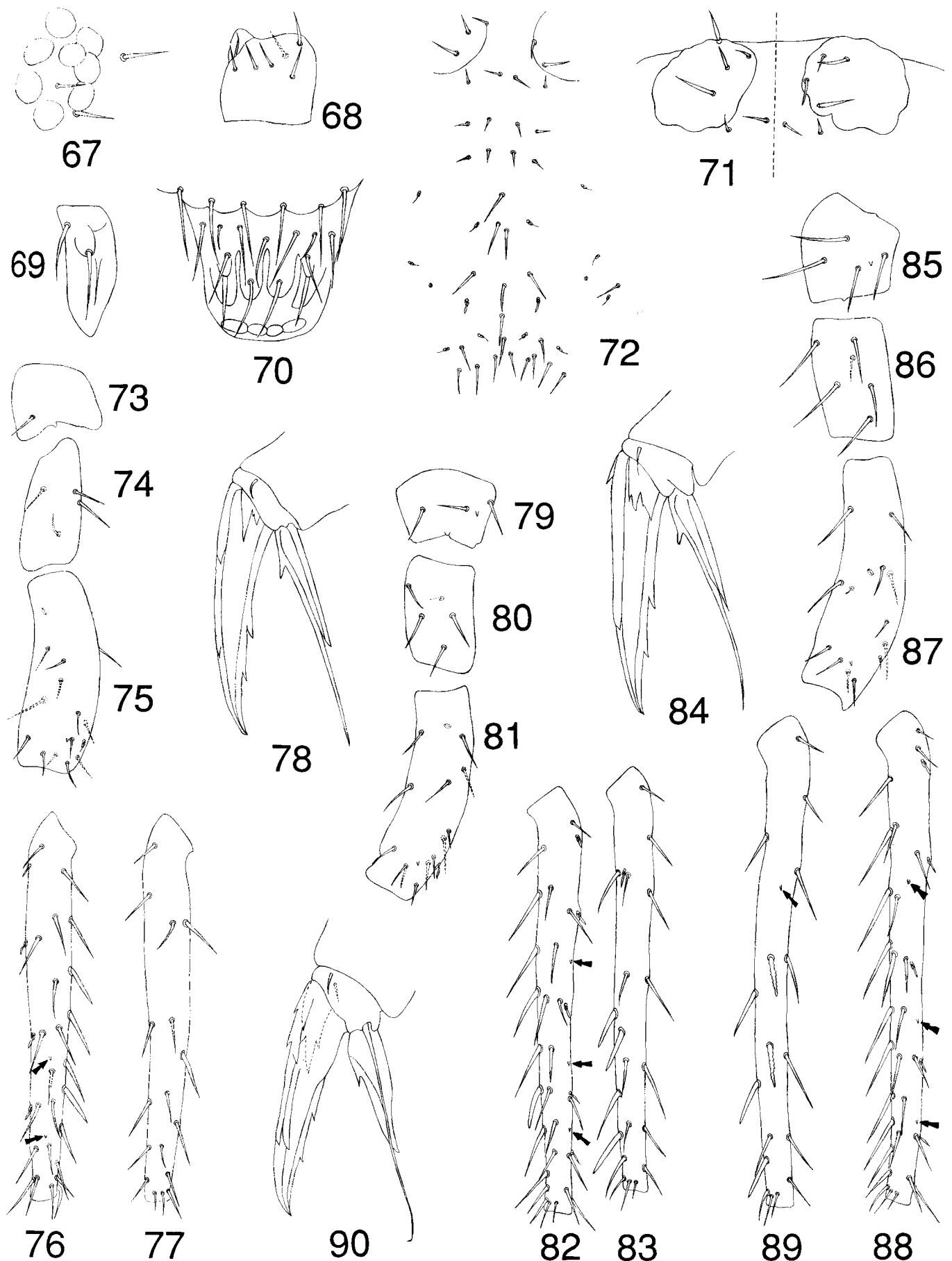
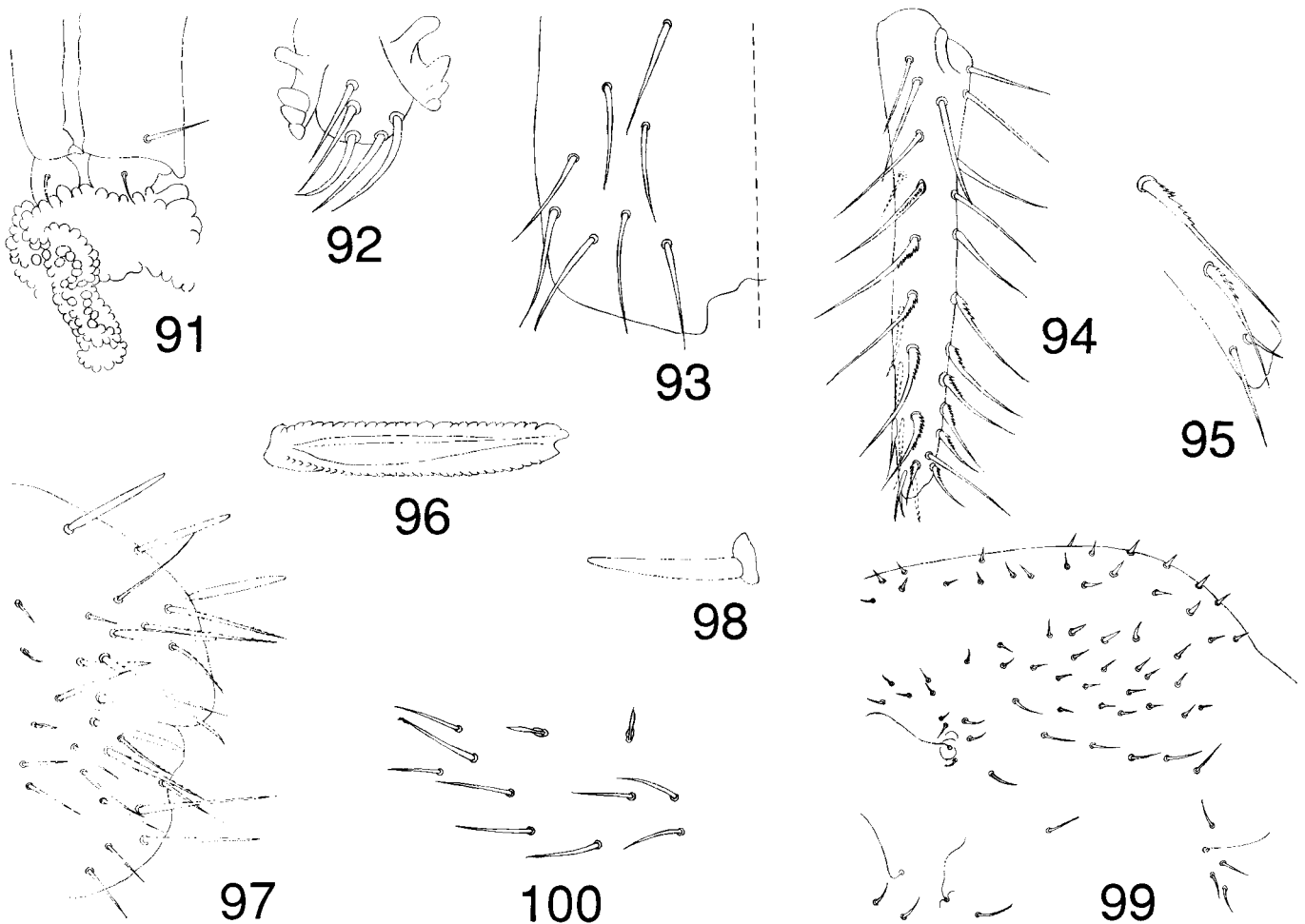


Fig. 66. *Ptenothrix* (*Papirioides*) *serrata* sp.n., habitus. Total length up to 2.2 mm.



Figs 67-90. *Ptenothrix (Papirioides) serrata* sp.n.—67. Right eyepatch.—68. Antennal segment I.—69. Outer maxillary lobe.—70. Labrum.—71. Dorsal setae of head.—72. Median facial setae.—73. Forecoxa.—74. Foretrochanter.—75. Forefemur.—76. Foretibiotsarsus, anterior surface.—77. Foretibiotsarsus, posterior surface.—78. Foreclaw.—79. Mesocoxa.—80. Mesotrochanter.—81. Mesofemur.—82. Mesotibiotsarsus, anterior surface.—83. Mesotibiotsarsus, posterior surface.—84. Mesoclaw.—85. Metacoxa.—86. Metatrochanter.—87. Metafemur.—88. Metatibiotsarsus, anterior surface.—89. Metatibiotsarsus, posterior surface.—90. Metaclaw.



Figs 91–100. *Ptenothrix (Papiroides) serrata* sp.n.—91. Collophore.—92. Corpus of retinaculum.—93. Manubrium, dorsal surface.—94. Dens.—95. Dental setae E_1 – E_3 .—96. Mucro.—97. Anal papilla, female.—98. Female subanal appendage.—99. Chaetotaxy of abdomen, lateral view.—100. Parafulcrular setae.

Wailua River, crossing on paved road, inland from Experiment Station, rotten wood, soil and vegetation, 18 January 1967, 4 specimens on slide and 5 in ethanol; Mauna Kapu, Waianae Mountains, litter under *Casuarina* sp., 20 October 1966, P. F. Bellinger.

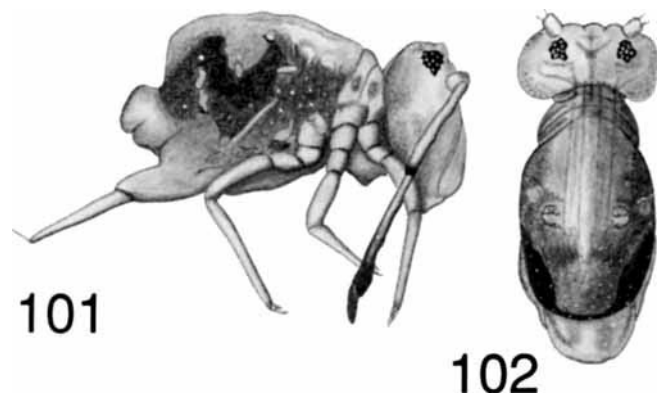
Description

Color. Background cream to light yellow with purple pigment dusting and irregular polygons. Head with interocular macula of light purple; light polygons on frons with macula between antennal bases and slightly below; purple increases on gena and becomes heaviest on post-gena; antenna with ANT I light purple, ANT II becoming dark distally, ANT III and IV dark purple. Body with thoracic segmentation outlined in light purple; dorsally with a faint colorless stripe originating at the first thoracic segment and terminating $3/4$ distance of abdomen; posterior abdominal region light purple with setal sockets colorless; laterally thorax to abdomen with dark purple, interspersed with irregular maculae; lesser abdomen dusted with light purple; legs light purple; furcula cream with light purple dusting at base of dens (Figs 101, 102).

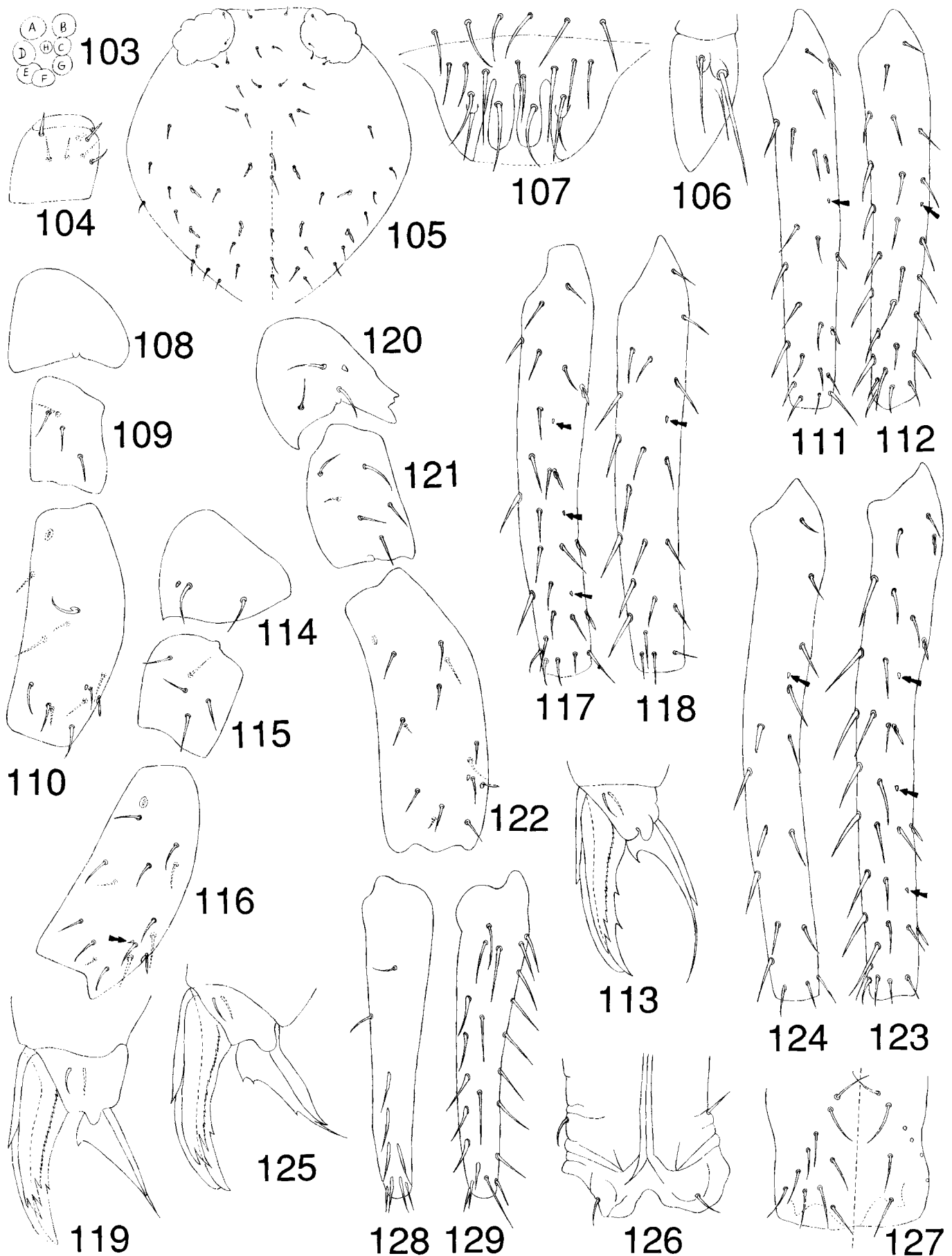
Morphology. Eyes $8 + 8$; ocellus D $1/2$ diameter of E, all other ocelli subequal (Fig. 103). Mean antennal ratio 4:13:18:4; ANT I with 4 dorsal and 3 ventral setae (Fig. 104); ANT II with 2 dorsal and 1 ventral cup sensilla; ANT III not subsegmented, subapical sensilla exposed,

lying in shallow depressions; ANT IV not subsegmented. Dorsal setae of head small, not spine-like; 5 unpaired median facial setae and oval organs lacking (Fig. 105); outer maxillary lobe consists of simple palp and 1 sublobal hair (Fig. 106). Labrum with setal pattern 6/5, 5, 4 (Fig. 107).

Foreleg. Coxa without seta or oval organ (Fig. 108); trochanter with 3 anterior and 1 posterior setae (Fig. 109); femur with posterior oval organ and distal anterior "courte épine", and outer cup sensilla (Fig. 110); tibiotarsus with 4 cup sensilla and 1 "courte épine" on anterior



Figs 101–102. *Dicyrtoma (Calvatomina) madestris* sp.n.—101. Habitus, lateral view.—102. Habitus, dorsal view. Total length up to 1 mm.



Figs 103–129. *Dicyrtoma (Calvatomina) madestris* sp.n.—103. Left eyepatch.—104. Antennal segment I.—105. Facial setae.—106. Outer maxillary lobe.—107. Labrum.—108. Forecoxa.—109. Foretrochanter.—110. Forefemur.—111. Foretibia, anterior surface.—112. Foretibia, posterior surface.—113. Foreclaw.—114. Mesocoxa.—115. Mesotrochanter.—116. Mesofemur.—117. Mesotibia, anterior surface.—118. Mesotibia, posterior surface.—119. Mesoclaw.—120. Metacoxa.—121. Metatrochanter.—122. Metafemur.—123. Metatibia, anterior surface.—124. Metatibia, posterior surface.—125. Metaclaw.—126. Collophore.—127. Manubrium, dorsal surface.—128. Dens, ventral surface.—129. Dens, dorsal surface.

Table III. Morphological differences between *Dicyrtoma* (*Calvatomina*) *madestris* sp.n. and *Dicyrtoma* (*Calvatomina*) *yaeyamensis* Yosii

	<i>madestris</i>	<i>yaeyamensis</i>
Inner ungual teeth	2-1-1	2-2-2
Dental setae E, L	9E, 10L	9E, 9L
Circumanal seta M	Spine-like	Setaceous
Circumanal seta T	Setaceous	Spine-like
Manubrial setae	10 + 10	9 + 9

surface (Fig. 111), posterior surface with 1 “courte épine” (Fig. 112); pretarsus with anterior and posterior setula; unguis with 1 outer tooth, tunica and pseudonychia; unguiculus with well-developed corner tooth, subapical filament 1/2 length of inner margin of unguis, reaching beyond its tip (Fig. 113).

Mesoleg. Coxa with 2 anterior and 1 posterior setae (Fig. 114); trochanter with 4 anterior and 1 posterior setae (Fig. 115); femur with posterior oval organ and distal “courte épine” and outer cup sensillum (Fig. 116); tibiotarsus with 4 cup sensilla and 3 “courtes épines” on anterior surface (Fig. 117), posterior surface with 1 “courte épine” (Fig. 118); pretarsus with anterior and posterior setulae; unguis with outer tooth, 1 inner tooth, tunica and pseudonychia; unguiculus with corner tooth, subapical filament short, 1/5 length of inner margin of unguis (Fig. 119).

Metaleg. Coxa with 3 anterior setae and 1 “courte épine” (Fig. 120); trochanter with 4 anterior and 1 posterior setae (Fig. 121); femur with posterior oval organ and distal “courte épine”, outer cup sensillum (Fig. 122); tibiotarsus with 5 cup sensilla and 3 “courtes épines” on anterior surface (Fig. 123) posterior surface with 1 “courte épine” (Fig. 124); pretarsus with anterior and posterior setulae; unguis with outer tooth, 1 inner tooth, tunica and pseudonychia; unguiculus with corner tooth (sometimes 2) and occasionally a distal tooth (sometimes 2), subapical filament 1/4 length of inner margin of unguis (Fig. 125).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae (Fig. 126), sacs warty. Corpus of tenaculum with 4 setulae, ramus with 3 teeth and basal horn. Manubrium with 10 + 10 dorsal setae (Fig. 127). Dens with 4, 2, 1, 1 . . . 1 Ve setae (Fig. 128), dorsal E and L setae all smooth (Fig. 129), $E_1/E_2 = 1.0-1.25$, $E_3/E_2 = 0.90-1.10$. Mucro with numerous inner and outer teeth, irregular (Fig. 130). Circumanal setae which follows pattern for subgenus M' is reduced and finely setaceous

M	N	A ₀	T	H	G	and	L
+	+	+	-	+	0		+

(Figs 131, 132). Female subanal appendage acuminate, slightly curved (Fig. 133). Parafucular setae commonly with 5(6) spine-like ciliated setae (Fig. 134). Length up to 1 mm.

Diagnosis. *Dicyrtoma* (*Calvatomina*) *madestris* sp.n. is a member of the “*rufescens* group” of Yosii, 1969. It comes closest to *Dicyrtoma* (*Calvatomina*) *yaeyamensis* Yosii, 1965. The differences between the two species are listed in Table III.

Dicyrtoma (*Calvatomina*) *sylvestratilis* sp.n.
(Figs 135-167)

Material examined. Holotype (♀) and 7 paratypes on slides. Hawaii, Kauai County, Kauai, Wailua-Hanalei Trail, 2 miles from paved road on Wailua side, rotten wood, fern litter and under bark, 18 January 1967. Paratype; same location, sweeping, 3 paratypes. P. F. Bellinger; Honolulu County, Oahu, Mt. Tantalus, 1000 feet elev., pan trap, *Acacia* sp. and *Cereus* sp., 22 October 1966, J. Vockeroth.

Description

Color. (Description based on specimens mounted on slides in Hoyer's medium.) Background yellow to opaque with purple distributed in the following patterns. Head with rose-purple reaching below eyepatches, dark macula between eyes, remaining area yellow-cream; antenna rose-purple basally becoming darker distally. Body with purple-brown reaching laterally, sometimes dorsum very light, giving the appearance of lateral stripes; lesser abdomen cream; legs with light dusting of rose-purple (Fig. 135).

Morphology. Eyes 8 + 8, ocelli subequal (Fig. 136). Mean antennal ratio 4:20:23:5; ANT I with 5 dorsal and 2 ventral setae (Fig. 137); ANT II with 2 dorsal and 1 ventral cup sensilla; ANT III not subsegmented, armed with cup sensilla, subapical sensilla exposed, lying in shallow depressions; ANT IV not divided into sub-segments. Outer maxillary lobe consists of simple palp and 1 sublobal hair (Fig. 138). Labrum with setal pattern 6/5, 5, 4. Dorsal setae of head reduced; 5-7 unpaired facial setae (Fig. 139).

Foreleg. Coxa with 1 seta (Fig. 141); trochanter with 2 anterior and 2 posterior setulae (Fig. 141); femur with 5 anterior and 5 posterior setae, 2 posterior setulae, outer cup sensillum, posterior basal oval organ elongated, anterior distal “courte épine” (Fig. 142); tibiotarsus with 4 cup sensilla and 3 “courtes épines” on anterior surface (Fig. 143), 1 “courte épine” on posterior surface (Fig. 144); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth, 2 small inner teeth; unguiculus with small corner tooth, subapical filament tapering, about length of lamella, reaching beyond tip of unguis (Fig. 145).

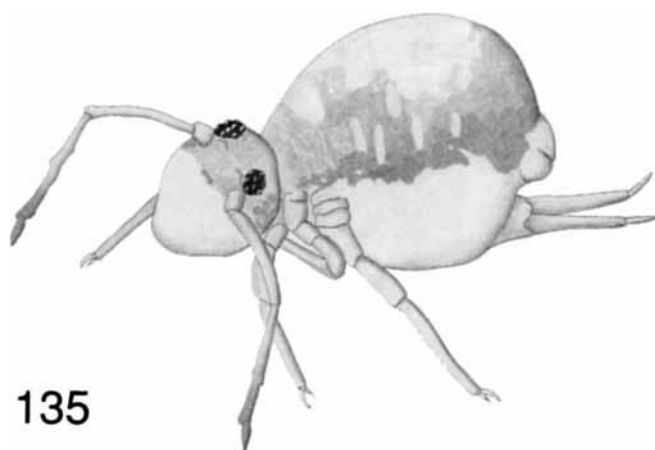


Fig. 135. *Dicyrtoma* (*Calvatomina*) *sylvestratilis* sp.n., habitus, lateral view. Total length up to 1.1 mm.

Table IV. Morphological differences between *Dicyrtoma* (*Calvatomina*) *sylvestratilis* sp.n., *Dicyrtoma* (*Calvatomina*) *solomonensis* (Yosii), and *Dicyrtoma* (*Calvatomina*) *modesta* (Yosii)

	<i>sylvestratilis</i>	<i>solomonensis</i>	<i>modesta</i>
Macrochaetae M, N, N' blunt, of equal length	N' 1/2 length of N and blunt	N' 1/2 length of N and setaceous	N' 1/2 length of N and almost setaceous
G-seta setaceous	Yes	Yes	No, blunt
A ₃ seta smaller than A ₄	Subequal	Yes	Yes
Dorsal dental setae	7L, 10E, D ₁ reduced (D ₁ 1/4 length of D ₂)	10L, 10E, D ₁ normal (D ₁ and D ₂ subequal)	10L, 9E, D ₁ normal (D ₁ and D ₂ subequal)

Mesoleg. Coxa with 3 setae and 1 "courte épine" (Fig. 146); trochanter with 3 anterior and 1 posterior setae (Fig. 147); femur with 7 anterior setae and 2 posterior setulae, outer cup sensillum, posterior basal oval organ elongated, anterior distal "courte épine" (Fig. 148); tibiotarsus with 5 cup sensilla and 3 "courtes épines" on anterior surface (Fig. 149), 1 "courte épine" on posterior surface (Fig. 150); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth, 2 inner teeth; unguiculus with corner tooth, subapical filament short, reaching tip of unguiculus (Fig. 151).

Metaleg. Coxa with 3 setae and 1 "courte épine" (Fig. 152); trochanter with 4 anterior and 1 posterior setae (Fig. 153); femur with 8 anterior and 2 posterior setae, 1 posterior setula, posterior oval organ elongated, distal anterior "courte épine" and outer "courte épine" (Fig. 154); tibiotarsus with 5 cup sensilla and 3 "courtes épines" on anterior surface (Fig. 155), posterior surface with 1 "courte épine" (Fig. 156); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth, 2 inner teeth; unguiculus, with corner tooth, subapical filament short, reaching beyond tip of unguis (Fig. 157).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae, sacs warty. Corpus of tenaculum with 4 setae, ramus with 3 teeth and basal horn (Fig. 158). Manubrium with 9 + 9 dorsal setae (Fig. 159). Dens with 4, 2, 1, 1 . . . 1 Ve setae (Fig. 160), dorsal E and L setae all smooth (Fig. 161), $E_1/E_2 = 1.20-1.40$, $E_3/E_2 = 1.30$ (Fig. 162). Mucro with numerous inner and outer teeth (Fig. 163). Circumanal setae follow pattern for subgenus

M	N	A ₀	T	H	G	and	L	M'
+	+	-	-	+	-		+	+

(Fig. 164); female subanal appendage straight, slightly curved and sharply tapered at apex. Parafurcular setae spine-like and ciliated (Fig. 165). Bothriothrix A and C very reduced, B normal (Fig. 166). Body setae fine in thoracic region, becoming spine-like posteriorly (Fig. 167). Length up to 1.1 mm.

Diagnosis. *Dicyrtoma* (*Calvatomina*) *sylvestratilis* sp.n. in many respects resembles *Dicyrtoma* (*Calvatomina*) *solomonensis* (Yosii, 1969) and *Dicyrtoma* (*Calvatomina*) *modesta* (Yosii, 1969), both from the Solomon Islands. Clearly they share the same labral setal pattern, 4 tentacular setae, 1 + 1 and 1 + 1 collophore setae, Ve setal pattern 4, 2, 1, 1 . . . 1 and inner margin of unguis with 1, 2, 2, teeth. However the circumanal macrochaetae pattern may be used to separate the 3 species as shown in Table IV.

Dicyrtoma (*Calvatomina*) *brevifibra* sp.n. (Figs 168–192)

Material examined. Holotype (♀) and 2 paratype on slides. Hawaii, Kalawao County, Molokai, vicinity of Kalahuapueo lookout, scrub forest, 12 January 1983, K. A. Christiansen, holotype; Hawaii County, Hawaii, Kukuihaele, unidentified bird's nest, 14 December 1961, Wilson, collector, paratype. Honolulu County, Oahu, Manoa Falls trail, flats near beginning, litter, 23 September 1966, P. F. Bellinger.

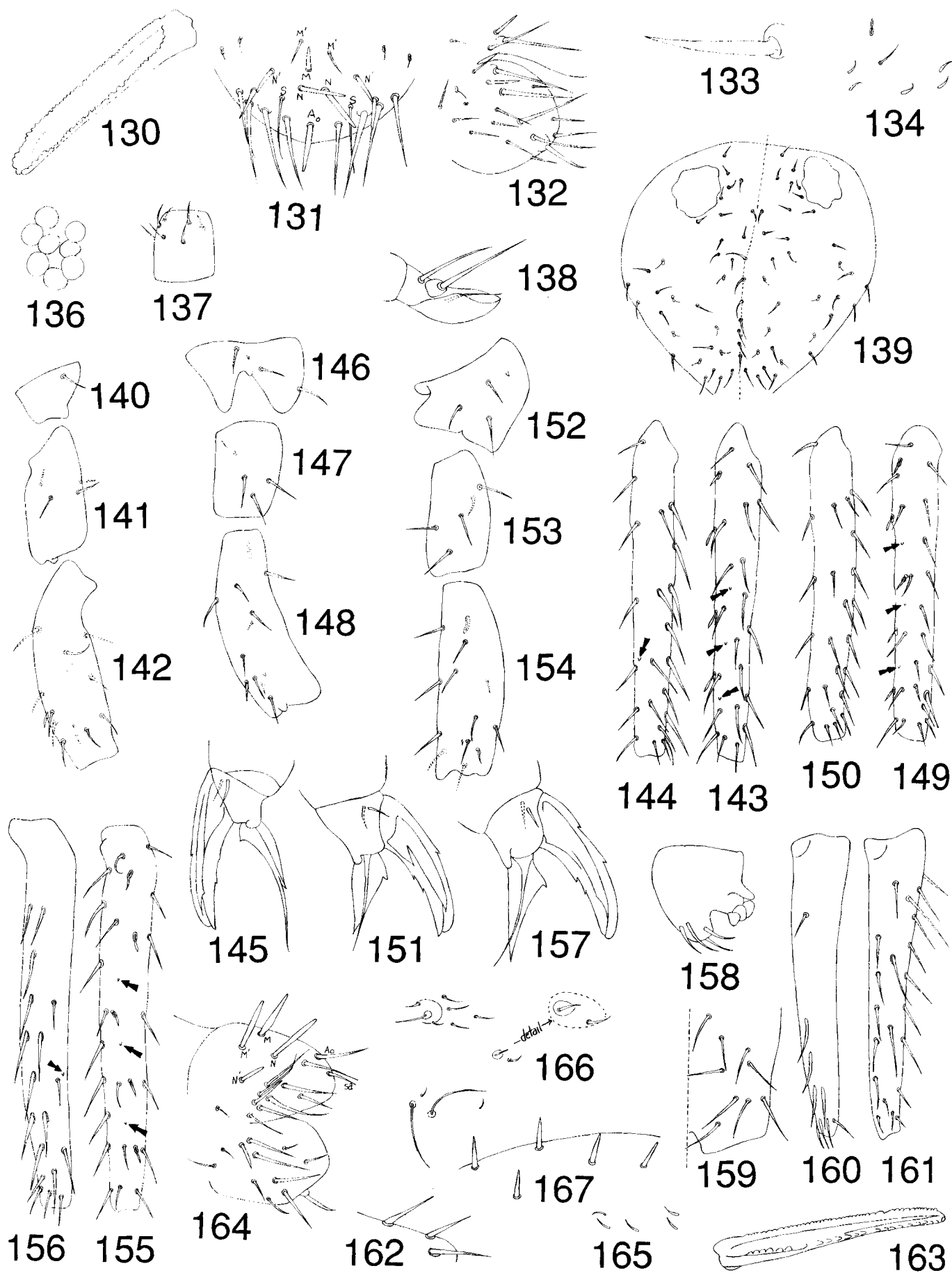
Description

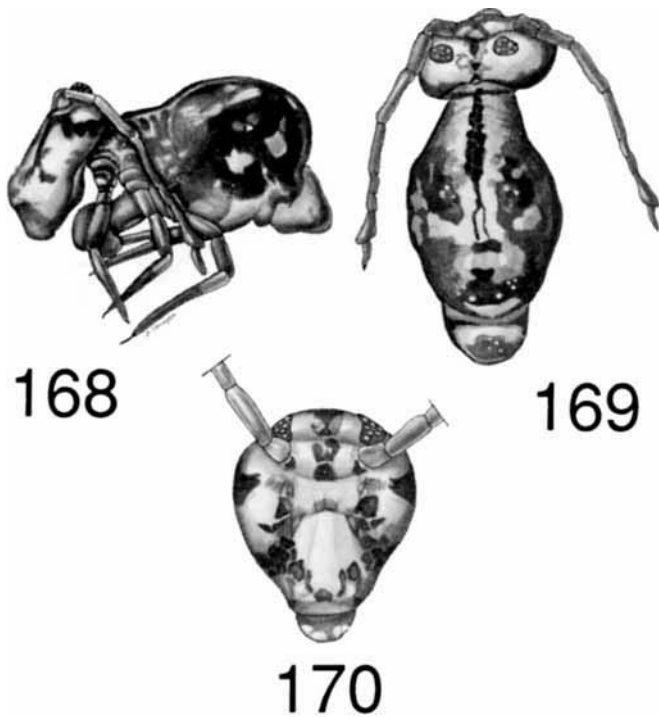
Color. (Description based on specimen preserved in ethanol.) Background white with dark blue pattern. ANT I with distal blue ring; ANT II light blue, becoming dark blue distally; ANT III light blue basal 1/4, dark blue distally; ANT IV dark blue. Vertex of head light blue with interocular macula dark blue, extending just below antennal bases; upper frons with light blue macula, lower frons to labrum blue, surrounding area white; gena with dark blue forming a stripe that extends to occiput, with a stripe of blue extending from antennal bases to mouthparts. Thoracic segments laterally blue, forming horizontal stripes dorsally, segments lined with white and scattered white maculae. Abdomen dark blue with dark blue stripe originating at thorax and terminating at apex before anal valves, this stripe is bordered with white; laterally with scattered white maculae roughly forming a square; anal valves dorsally light with dark apical macula. Manubrium light blue, dens white. Collophore light blue. Legs with coxa and trochanter dark blue, femur dark blue distally, otherwise white, tibiotarsus light blue distal 3/4 (Figs 168–170).

Morphology. Eyes 8 + 8, ocelli subequal (Fig. 171). Mean antennal ratio 4:15:21:5; ANT I with 5 dorsal and 2 ventral setae (Fig. 172); ANT II with 2 dorsal and 1 ventral cup sensilla; ANT III not subsegmented, armed with cup sensilla, subapical sensilla exposed, lying in shallow depressions; ANT IV not divided into subsegments. Dorsal setae of head reduced; 5 unpaired facial setae (Fig. 173).

Foreleg. (Only claw adequate for description.) Pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, 1 outer tooth and single inner tooth; unguiculus without corner tooth, subapical filament tapering beyond tip of unguis (Fig. 174).

Mesoleg. Coxa with 3 anterior setae; femur with 5 anterior and 5 posterior setae, with outer cup sensillum, anterior and posterior setulae (Fig. 175); (tibiotarsus inadequate); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, 2 outer teeth and 2 fine inner teeth; unguiculus with corner tooth, subapical filament tapering beyond tip of unguis (Fig. 176).





Figs 168–170. *Dicyrtoma (Calvatomina) brevifibra* sp.n.—168. Habitus, lateral view.—169. Habitus, dorsal view.—170. Head, frontal view.

Metaleg. Coxa with 4 anterior setae (Fig. 177); trochanter with 4 anterior and 1 posterior setae (Fig. 178); femur with 8 anterior and 3 posterior setae, basal oval organ, distal setula and outer cup sensillum (Fig. 179); tibiotarsus with 5 cup sensilla and 3 “courtes épines” on anterior surface (Fig. 180), posterior surface with 1 “courte épine” (Fig. 181); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, 2 outer teeth and 2 inner fine teeth; unguiculus with corner tooth, subapical filament tapering, short and fine, reaching beyond tip of unguis (Fig. 182).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae, sacs warty (Fig. 183). Corpus of tenaculum with 4 setae, ramus with 3 teeth and basal horn (Fig. 184). Manubrium with 9 + 9 dorsal setae and 1 + 1 cup sensilla (Fig. 185). Dens with 4, 2, 1, 1 . . . 1 Ve setae (Fig. 186), dorsal E and L setae smooth (Fig. 187), $E_1/E_2 = 0.81$, $E_3/E_2 = 1.60$ (Fig. 188). Mucro with numerous inner and outer teeth (Fig. 189). Circumanal setae follow the pattern for the genus

M	N	A ₀	T	H	G	and	L	M'
+	+	—	—	+	+		+	+

(Fig. 190), N' short, spine-like; female subanal appendage acuminate, slightly curved (Fig. 191). Parafurcular area with 3 spine-like, ciliated setae and 2 setaceous (Fig.

192). Bothriothrix A and C normal, B missing, represented by cup sensillum only, D missing. Body setae in thoracic region fine, become spine-like posteriorly. Length up to 1 mm.

Diagnosis. *Dicyrtoma (Calvatomina) brevifibra* sp.n. is allied to the *formosana* group of Yosii (1969) by virtue of the M, M', N, N' setal pattern, as well as similar parafurcular setal pattern. However, the presence of dorsal cup sensilla (1 + 1) on the manubrium, 7L, 9E dorsal setae on dens, and striking color pattern will separate the species from the *formosana* group and Hawaiian species. Further collecting will no doubt improve the description presented here.

Dicyrtoma (Calvatomina) tessellata sp.n. (Figs 193–225)

Material examined. Holotype (♀) and 5 paratypes on slides. Hawaii, Honolulu County, Oahu, below Pali above Anouai Pl., upper Manoa Valley, dead leaves among loose rocks, 30 November 1966, P. F. Bellinger (holotype). Oahu (30 November 1966), 2 on slide. Oahu, Mt. Tantalus, rotten wood in bamboo stand, 16 September 1966, P. F. Bellinger, 1 (♂). Oahu, Manoa Falls trail, flats near beginning, litter, 23 September 1966, P. F. Bellinger, 2 on slide.

Description

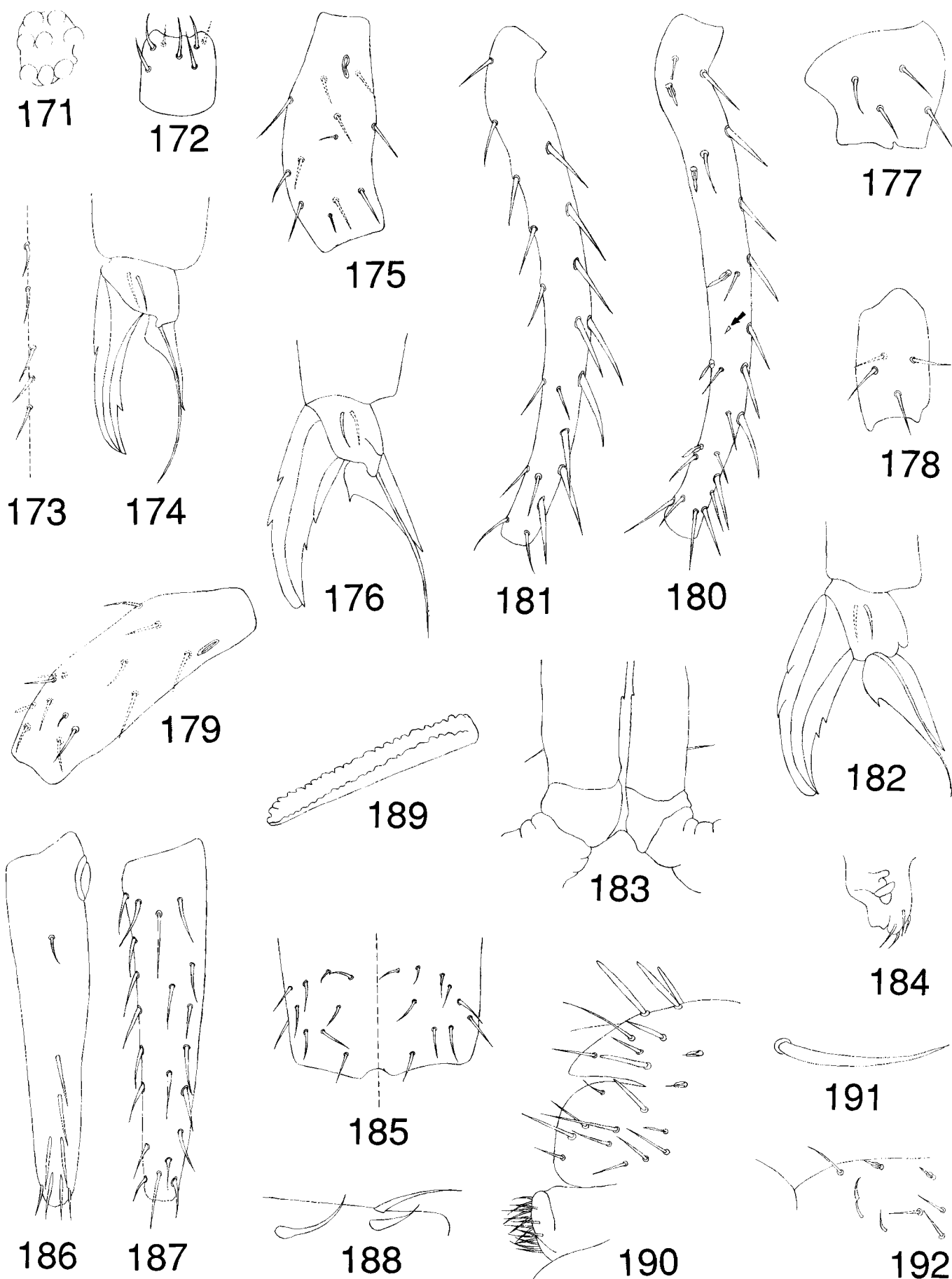
Color. (Description based on specimens mounted on slides in Hoyer's medium.) Background yellow with purple pigment laid down in irregular polygons. Antenna purple. Vertex of head with dark purple macula between eyepatches, light purple stripe connected to dark macula of frontal interocular area; lateral purple band on gena with light suffusion of purple. Body with dark purple lateral bands that join near the postero-dorsal area, anal papilla light purple. Legs with light purple, distal portion of femur darker. Furcula light purple on manubrium and dens, mucro with small amounts of purple (Fig. 193).

Morphology. Eyes 8 + 8, ocelli approximately subequal (Fig. 194). Mean antennal ratio 4:18.5:24:6.5; ANT I with 5 dorsal and 2 ventral setae (Fig. 195); ANT II with 2 dorsal and 1 ventral cup sensilla; ANT III not subsegmented, armed with cup sensilla, subapical sensilla exposed, lying in shallow depressions; ANT IV not subsegmented. Outer maxillary lobe consists of simple palp and 1 sublobal hair (Fig. 196). Labrum with setal pattern 6/5, 5, 4. Dorsal setae of head reduced; 5–6 unpaired facial setae (Fig. 197).

Foreleg. Coxa with 1 anterior seta (Fig. 198); trochanter with 2 anterior and 1 posterior setae (Fig. 199); femur with 5 anterior and 5 posterior setae, outer cup sensillum, posterior setula and basal oval organ (Fig. 200); tibiotarsus with 5 cup sensilla and 3 “courtes épines”

Figs 130–134. *Dicyrtoma (Calvatomina) madestris* sp.n.—130. Mucro.—131. Anal papilla, dorsal view.—132. Anal papilla, lateral view.—133. Female subanal appendage.—134. Parafurcular setae.

Figs 136–167. *Dicyrtoma (Calvatomina) sylvestratilis* sp.n.—136. Left eyepatch.—137. Antennal segment I.—138. Outer maxillary lobe.—139. Facial seta.—140. Forecoxa.—141. Foretrochanter.—142. Forefemur.—143. Foretibiotarsus, anterior surface.—144. Foretibiotarsus, posterior surface.—145. Foreclaw.—146. Mesocoxa.—147. Mesotrochanter.—148. Mesofemur.—149. Mesotibiotarsus, anterior surface.—150. Mesotibiotarsus, posterior surface.—151. Mesoclaw.—152. Metacoxa.—153. Metatrochanter.—154. Metafemur.—155. Metatibiotarsus, anterior surface.—156. Metatibiotarsus, posterior surface.—157. Metaclaw.—158. Corpus of retinaculum.—159. Manubrium, dorsal surface.—160. Dens, ventral surface.—161. Dens, dorsal surface.—162. Dental setae E_1 – E_3 .—163. Mucro.—164. Anal papilla, female.—165. Parafurcular setae.—166. Bothriothrix A–B.—167. Body setae, thoracic region.



Figs 171–192. *Dicyrtoma (Calvatomina) brevifibra* sp.n.—171. Left eyepatch.—172. Antennal segment I.—173. Unpaired facial setae.—174. Foreclaw.—175. Mesofemur.—176. Mesoclaw.—177. Metacoxa.—178. Metatrochanter.—179. Metafemur.—180. Metatibiotarsus, anterior surface.—181. Metatibiotarsus, posterior surface.—182. Metaclaw.—183. Collophore.—184. Corpus of retinaculum.—185. Manubrium, dorsal surface.—186. Dens, ventral surface.—187. Dens, dorsal surface.—188. Dental setae E_1-E_3 .—189. Mucro.—190. Anal papilla, male.—191. Female subanal appendage.—192. Parafurcular setae.



Fig. 193. *Dicyrtoma (Calvatomina) tessellata* sp.n., habitus, lateral view. Total length up to 1 mm.

on anterior surface (Fig. 201), posterior surface with 1 "courte épine" (Fig. 202); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, sometimes second outer tooth and 1 inner tooth; unguiculus with corner tooth, subapical filament about 1/2 length of inner edge of unguis, tapering just beyond tip of unguis (Fig. 203).

Mesoleg. Coxa with 3 anterior setae and 1 "courte épine" (Fig. 204); trochanter with 3 anterior and 2 posterior setae (Fig. 205); femur with 10 anterior and 2 posterior setae, outer cup sensillum, and basal oval organ (Fig. 206); tibiotarsus with 5 cup sensilla and 3 "courtes épines" on anterior surface (Fig. 207), 1 "courte épine" on posterior surface (Fig. 208); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth and 2 small inner teeth; unguiculus with corner tooth, subapical filament short, fine, reaching just beyond tip of unguis (Fig. 209).

Metaleg. Coxa with 4 anterior setae and 1 "courte épine" (Fig. 210); trochanter with 4 anterior and 1 small, fine posterior setae (Fig. 211); femur with 10 anterior and 1 posterior setae, outer cup sensillum, 2 posterior setulae and basal oval organ (Fig. 212); tibiotarsus with 5 cup sensilla, 3 "courtes épines" on anterior surface (Fig. 213), 1 "courte épine" on posterior surface (Fig. 214); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, sometimes outer tooth, subapical filament short, fine, tapering just beyond tip of unguis (Fig. 215).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae, sacs warty (Fig. 216). Corpus of tenaculum with 4 setae, ramus with 3 teeth and basal horn (Fig. 217). Manubrium with 9 + 9 setae (Fig. 218). Dens with 4, 2, 1, 1 . . . 1 Ve setae (Fig. 219), dorsal E and L setae all smooth (Fig. 220), $E_1/E_2 = 0.95-1.10$, $E_3/E_2 = 1.10-1.30$ (Fig. 221). Mucro with numerous inner and outer teeth (Fig. 222). Circumanal setae follow the pattern

M	N	A ₀	T	H	G	and	L	M'
+	+	-	-	+	+		+	+

(Fig. 223); female subanal appendage heavy, sharp, tapered and curved at apex (Fig. 224). Parafulcrular setal pattern 3 spine-like and 2 setaceous (Fig. 225). Bothriothrix A, B, C normal, D missing. Body setae fine in thoracic region, becoming spine-like posteriorly. Length up to 1 mm.

Diagnosis. *Dicyrtoma (Calvatomina) tessellata* sp.n. strongly resembles *Dicyrtoma (Calvatomina) brevifibra* sp.n. in many respects. It also has many characteristics of the "formosana group". Separation from the Hawaiian members of the genus is by 6L, 9E setae and $D_1 < D_2$ on the dens; in addition, *brevifibra* lacks a corner tooth on the fore-unguiculus and has 1 + 1 cup sensilla on the manubrium. The strong color pattern alone will distinguish this species from other Hawaiian dicyrtomids.

***Dicyrtoma (Calvatomina) microdentata* sp.n.**
(Figs 226–237)

Material examined. Holotype (♀) and paratype on one slide. Hawaii, Kauai County, Kauai, Kokce State Park, swept from long grass by road, 17 January 1967, P. F. Bellinger.

Description

Color. (Description based on specimen mounted on slide in Hoyer's medium.) Background cream-yellow with light purple pigment. Antenna light purple, becoming darker distally. Head with light dusting of purple on vertex, gena and postgenal areas. Body with fine granules of purple dorsally, becoming darker laterally, giving the appearance of lateral bands. Legs light purple. Furcula cream (Fig. 226).

Morphology. Eyes 8 + 8, ocelli A and B subequal, slightly larger than others (Fig. 227). Mean antennal ratio 4:19:21:6. ANT I with 5 dorsal and 2 ventral setae; antennal segments III and IV unsegmented, other features not clear. Dorsal setae of head fine; 5 unpaired facial setae. Outer maxillary lobe and labrum not seen. Coxae, trochanters, femora, and tibiotarsi not clear enough for illustration.

Foreleg. Tibiotarsus with 4 cup sensilla, 3 "courtes épines" on anterior surface, 1 "courte épine" on posterior; pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, 1 outer and 2 inner teeth; unguiculus with corner tooth and subapical filament over 1/2 length of inner edge of unguis, reaching beyond its tip (Fig. 228).

Mesoleg and Metaleg. Tibiotarsus with 5 cup sensilla, 3 "courtes épines" on anterior surface, posterior with 1 "courte épine"; pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, 1 outer and 2 inner teeth; unguiculus with corner tooth, subapical filament short, fine, about 1/3 length of inner margin of unguis (Fig. 229).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae (Fig. 230), sacs warty. Corpus of tenaculum with 4 setulae, ramus with 3 teeth and basal horn (Fig. 231). Manubrium with 9 + 9 dorsal setae (Fig. 232). Dens with 4, 2, 1, 1 . . . 1 Ve setae, dorsal setae smooth, 8L, 9E, E setae ratio $E_1/E_2 = 1.10$ and $E_3/E_2 = 1.20$ (Fig. 223). Mucro with numerous inner and outer teeth, teeth of inner margin much smaller than outer (Fig. 234). Circumanal setae follow pattern

M	N	A ₀	T	H	G	and	L	M'
+	+	+	-	+	-		+	-

(Fig. 235); female subanal appendage acuminate, curving (Fig. 236). Parafucular setal pattern 5 spine-like, ciliated setae (Fig. 237). Bothriothrix A, B, C normal, D missing. Body setae fine in thoracic region, becoming spine-like posteriorly. Length up to 1 mm.

Diagnosis. *Dicyrtoma* (*Calvatomina*) *microdentata* sp.n. like *Dicyrtoma* (*Calvatomina*) *maestrus* sp.n. falls within the “*rufescens* group” of Yosii (1969). The species may be separated on the basis of ungual configuration of the metalegs, manubrial setae, number of E, L setae on dens, and circumanal setae G. Another member of the “group”, *Dicyrtoma* (*Calvatomina*) *pagoda* (Yosii, 1966) exhibits most of the characteristics of *microdentata*. It can be separated by having 10L, 10E dental setae, lacking G seta on the anal valve and a distinctive color pattern. *Dicyrtoma* (*Calvatomina*) *yaeyamensis* (Yosii, 1965) is very similar, but can be distinguished from *microdentata* on the basis of color pattern, setaceous M' seta, blunt T seta and uniform teeth on mucro. The unique G seta, reduced to a setulae makes this species easy to identify.

***Dicyrtoma* (*Calvatomina*) *longidigita* sp.n. (Figs 238–256)**

Material examined. Holotype (♀) on slide. Hawaii, Hawaii County, Hawaii, Puu Pile Kohala Mountains, elev. 4500 feet, forest floor debris, 6 July 1964, Haas.

Description

Color. Purple with irregular light maculae. Appendages dark purple (Fig. 238).

Morphology. Eyes 8 + 8, subequal (Fig. 239). ANT I with 5 dorsal and 2 ventral setae (Fig. 240); ANT II with 2 dorsal and 1 ventral cup sensilla; ANT III not subsegmented, with cup sensilla and distal sensilla exposed, lying in depressions; ANT IV not subsegmented. Outer maxillary lobe consists of simple palp and 1 sublobal hair (Fig. 241). Labrum not seen. Dorsal setae of head short, fine; 5 unpaired facial setae (Fig. 242).

Foreleg. Coxa, trochanter and femur not clear or obscured in preparation; tibiotarsus with 3 cup sensilla and 1 (visible) “courte épine” on anterior surface (Fig. 243), posterior surface without “courte épine” (Fig. 244); pretarsus with anterior and posterior setulae; unguiculus with pseudonychia, tunica, up to 2 outer teeth and 2 inner teeth; unguiculus with 2 corner teeth, subapical filament heavy, tapering, longer than unguiculus (Fig. 245).

Mesoleg. Coxa, trochanter, and femur not clear or obscured in preparation; tibiotarsus with 5 cup sensilla and 2 “courtes épines” on anterior surface (Fig. 246), posterior surface without visible “courte épine” (Fig. 247); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth and 2 inner teeth; unguiculus with strong corner tooth and small second tooth, subapical filament heavy, tapering, longer than unguiculus (Fig. 248).

Metaleg. Coxa, trochanter and femur not clear or obscured; tibiotarsus with 5 cup sensilla and 3 “courtes épines” on anterior surface (Fig. 249), no visible “courte

Table V. *Morphological differences between Dicyrtoma* (*Calvatomina*) *longidigita* sp.n., *Dicyrtoma* (*Calvatomina*) *brevifibra* sp.n., *Dicyrtoma* (*Calvatomina*) *sylvestratilis* sp.n. and *Dicyrtoma* (*Calvatomina*) *tesselata* sp.n.

	<i>longidigita</i>	<i>brevifibra</i>	<i>sylvestratilis</i>	<i>tesselata</i>
Circumanal T seta present and setaceous	Yes	Absent	Yes	Absent
Parafurcular setae spine-like	3	3	5	3
Subapical filament to outer edge of metaunguiculus	1:1	1:2	1:3	1:2.75

épine” on posterior surface (Fig. 250); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth and 2 inner teeth; unguiculus with strong corner tooth and small second tooth, subapical filament heavy, tapering, as long as unguiculus (Fig. 251).

Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae, sacs warty. Corpus of tenaculum with 4 setulae, ramus with 3 teeth and basal horn. Manubrium not clear. Dens with 4, 2, 1, 1 . . . 1 Ve setae, other setae obscure, E and L setae smooth, $E_1/E_2 = 1.00$, $E_3/E_2 = 1.10$. Mucro with numerous inner and outer teeth (Fig. 252). Circumanal setae follow pattern

M	N	A ₀	T	H	G	and	M'	N'	L
+	+	–	–	+	–		+	±	+

(Fig. 253); female subanal appendage heavy, curved and sharply tapered at apex (Fig. 254). Parafucular setae 3 spine-like and 2 setaceous (Fig. 255). Bothriothrix D missing. Body setae fine in thoracic region, becoming spine-like posteriorly (Fig. 256). Length up to 2 mm.

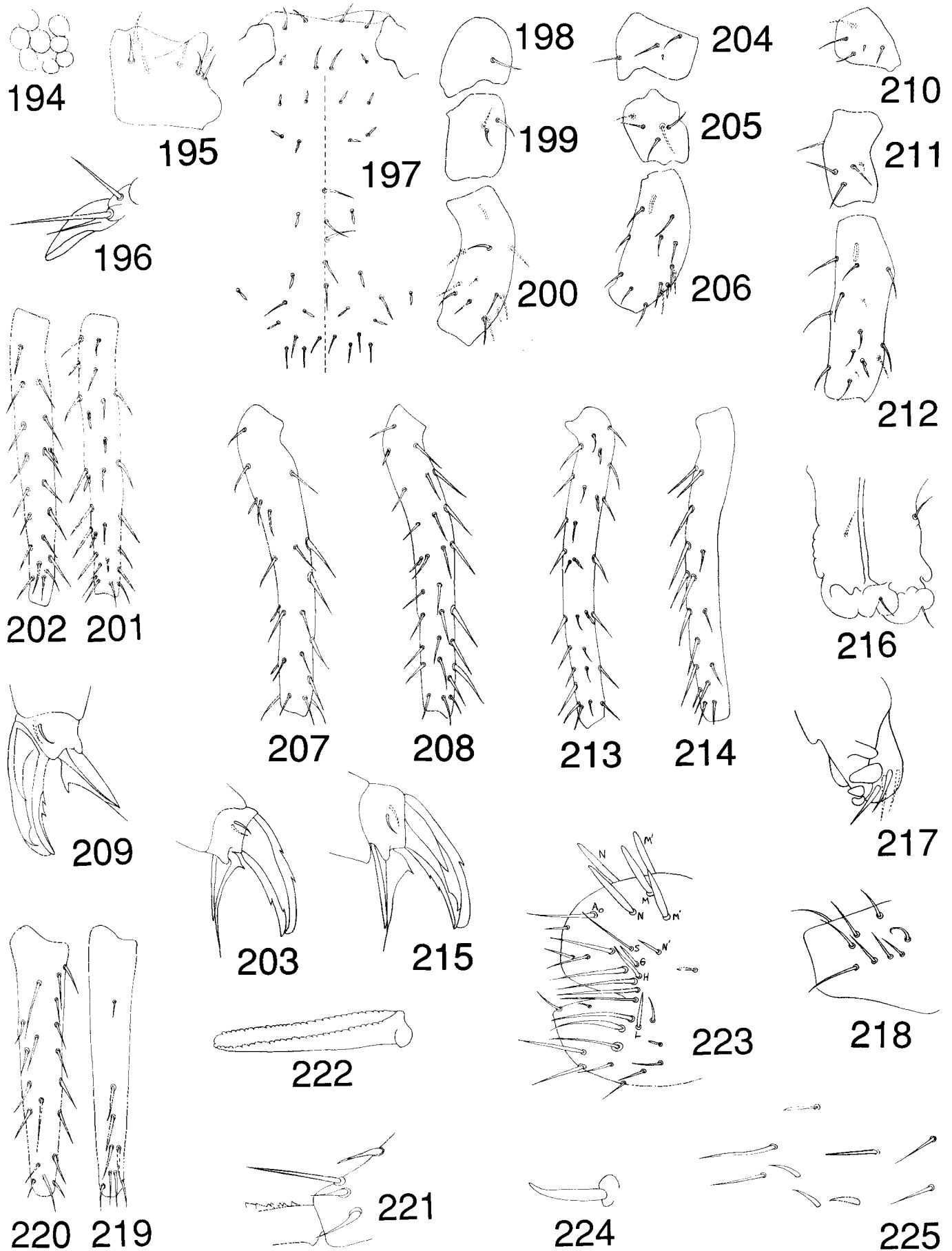
Diagnosis. *Dicyrtoma* (*Calvatomina*) *longidigita* sp.n. is a member of Yosii’s (1969) “*formosana* group”. It can be separated from *formosana* by having circumanal setae H spine-like and M' blunt, spine-like; *solomonensis* and *modesta* have the same circumanal setal pattern as *longidigita*, separation is possible on the basis of color pattern and shape of the claws. The Hawaiian species that come closest to *longidigita* are *brevifibra*, *sylvestratilis* and *tesselata*. Separation of the 4 species can be accomplished using the characteristics listed in Table V.

***Dicyrtoma* (*Calvatomina*) *bellingeri* sp.n. (Figs 257–289)**

Material examined. Holotype (♀) and 3 paratypes preserved in ethanol, 2 paratypes on slides. Hawaii, Kauai County, Kauai, Na Pali Wilderness Area, Hanakoa Campsite, forest, near stream, sifting litter, 22 March 1986, K. A. Christiansen.

Description

Color. Background opaque to white with brown-purple pigment laid down in irregular polygons. Antenna distally dark purple-blue, becoming lighter basally. Vertex of head with light purple macula between eyepatches and flanked by smaller, darker maculae. Frons with purple mosaics forming an irregular band extended to postgenal area. Lower frons with medial macula, frontal oral area bordered with purple mosaics. Body with purple lateral



Figs 194–225. *Dicyrtoma (Calvatomina) tessellata* sp.n.—194. Left eyepatch.—195. Antennal segment I.—196. Outer maxillary lobe.—197. Facial setae.—198. Forecoxa.—199. Foretrochanter.—200. Forefemur.—201. Foretibiotsarsus, anterior surface.—202. Foretibiotsarsus, posterior surface.—203. Foreclaw.—204. Mesocoxa.—205. Mesotrochanter.—206. Mesofemur.—207. Mesotibiotsarsus, anterior surface.—208. Mesotibiotsarsus, posterior surface.—209. Mesoclaw.—210. Metacoxa.—211. Metatrochanter.—212. Metafemur.—213. Metatibiotsarsus, anterior surface.—214. Metatibiotsarsus, posterior surface.—215. Metaclaw.—216. Collophore.—217. Corpus of retinaculum.—218. Manubrium, lateral view.—219. Dens, ventral surface.—220. Dens, dorsal surface.—221. Dental setae E₁-E₃.—222. Mucro.—223. Anal papilla, female.—224. Female subanal appendage.—225. Parafurcular setae.

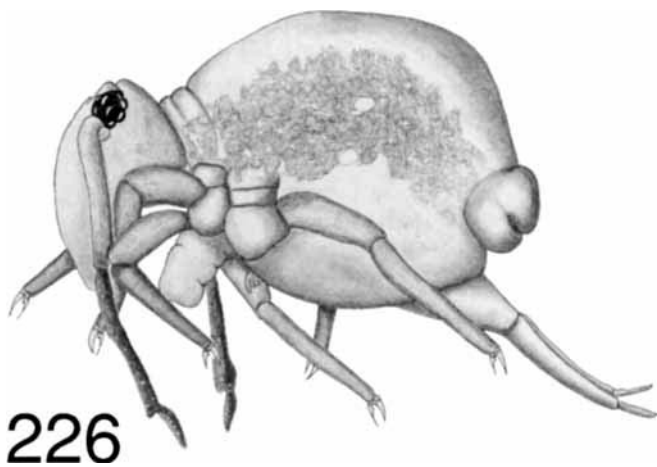


Fig. 226. *Dicyrtoma (Calvatomina) microdentata* sp.n., habitus, lateral view. Total length up to 1 mm.

band becoming darker posteriorly; a large purple V postero-dorsally and pair of light purple rectangular patches. Upper and lower valves of anal papilla with ventral purple spots. Legs from lower femur distally with purple-blue, colophore and furcula with light purple dusting (Figs 257, 258).

Morphology. Eyes 8 + 8, ocelli subequal. Mean antennal ratio 4:15:18:5; ANT I with 5 dorsal and 2 ventral setae; ANT II with 2 dorsal and 1 ventral cup sensilla; ANT III not subsegmented, armed with cup sensilla, subapical sensilla exposed, lying in shallow depressions; ANT IV not subsegmented. Outer maxillary lobe consists of simple palp and 1 sublobal hair (Fig. 259). Labrum with setal pattern 6/5, 5, 4. Dorsal setae of head reduced, small (Fig. 260); 6 unpaired facial setae (Fig. 261).

Foreleg. Coxa with 1 anterior seta (Fig. 262); trochanter with 3 anterior and 1 posterior setae (Fig. 263); femur with 5 anterior and 5 posterior setae, 2 posterior setulae, outer cup sensillum, anterior "courte épine" and basal posterior oval organ (Fig. 264); tibiotarsus with 4 cup sensilla and 3 "courtes épines" on anterior surface

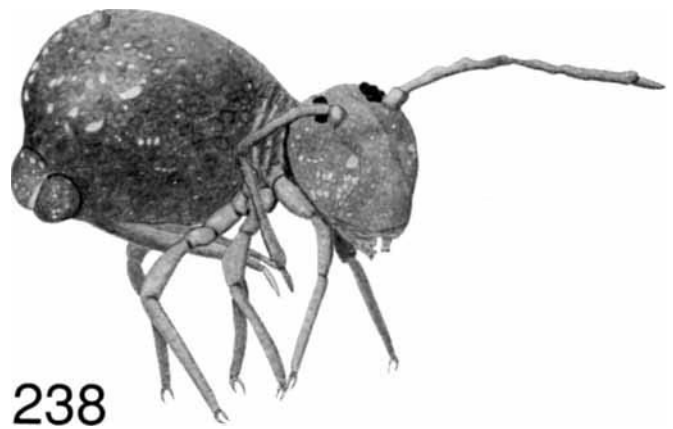
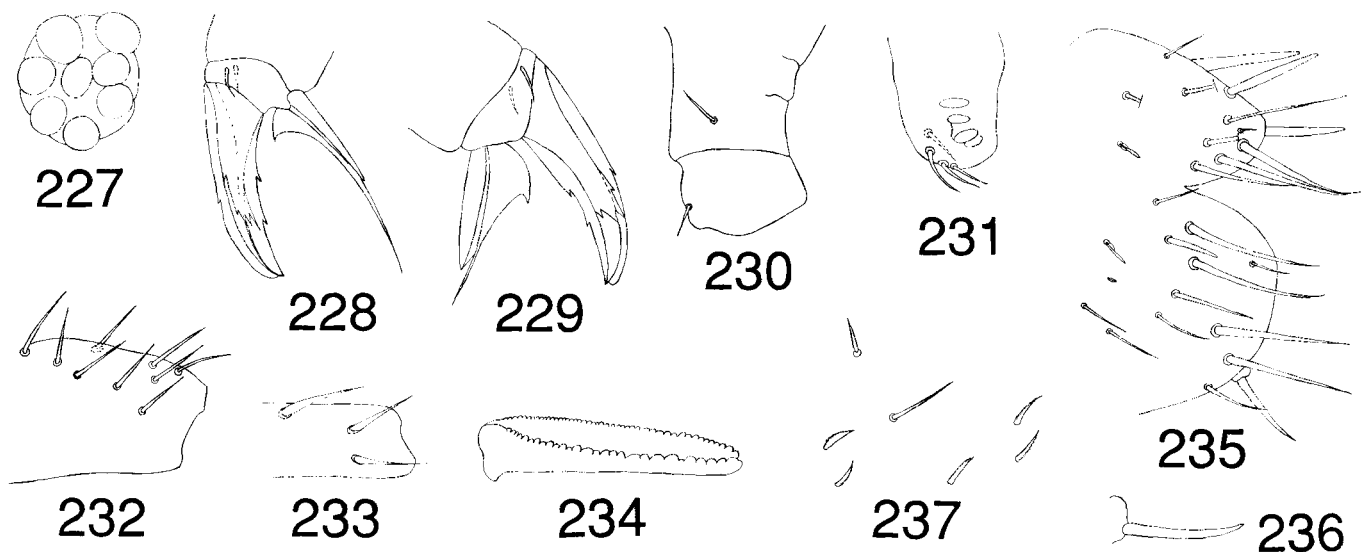


Fig. 238. *Dicyrtoma (Calvatomina) longidigita* sp.n., habitus, lateral view. Total length up to 2 mm.

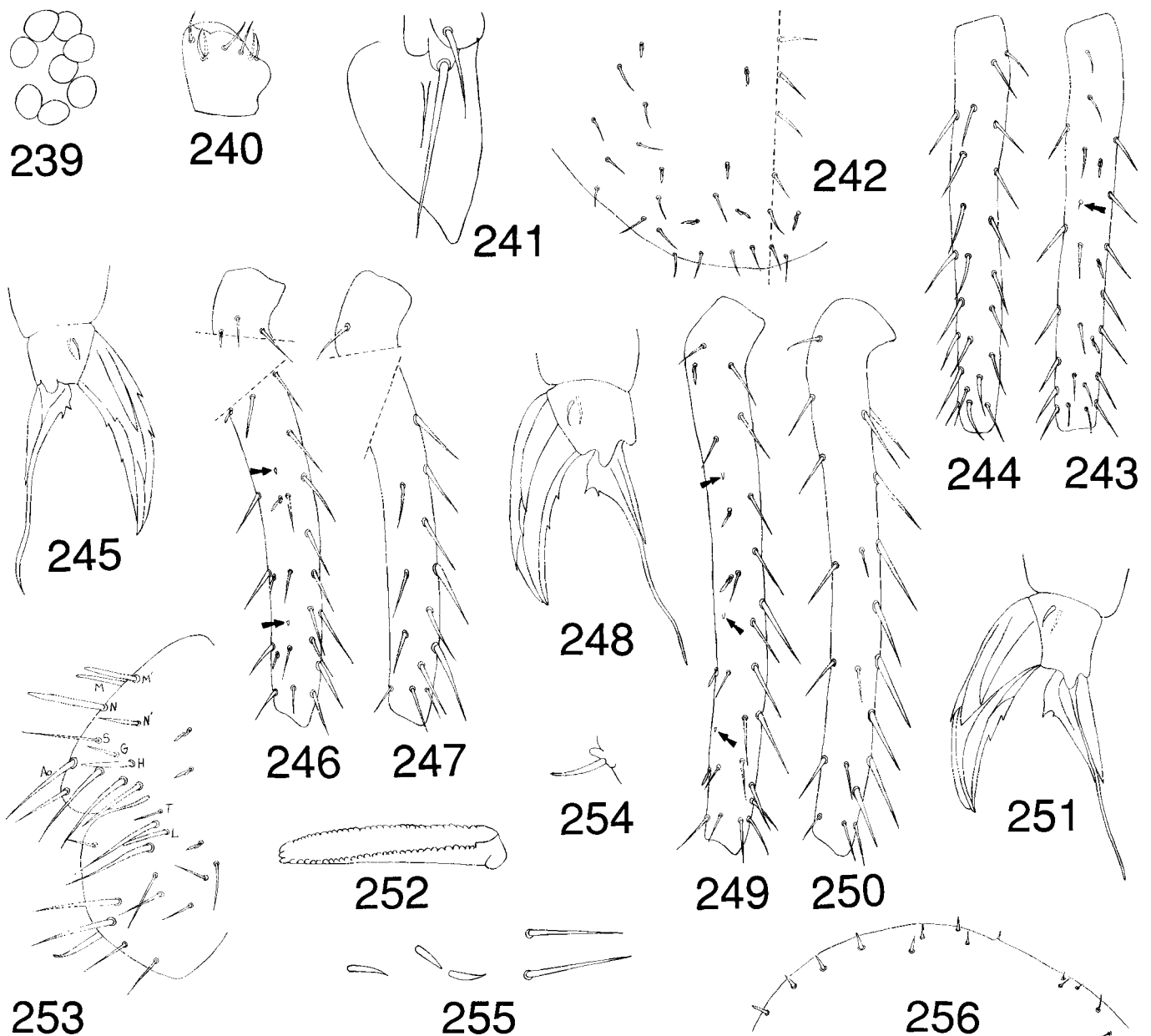
(Fig. 265), posterior surface with 1 "courte épine" (Fig. 266); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth, and 2 inner teeth; unguiculus with sharp, straight corner tooth, subapical filament over 1/2 length of inner edge of unguis, tapering beyond tip of unguis (Fig. 267).

Mesoleg. Coxa with 3 anterior setae and 1 "courte épine" (Fig. 268); trochanter with 3 anterior and 1 posterior setae (Fig. 269); femur with 9 anterior and 3 posterior setae, outer cup sensillum, 2 posterior setulae, 1 anterior "courte épine" and basal posterior oval organ (Fig. 270); tibiotarsus with 5 cup sensilla and 3 "courtes épines" on anterior surface (Fig. 271), 1 "courte épine" on posterior surface (Fig. 272); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth and 2 inner teeth; unguiculus with 2 corner teeth and small subapical tooth, subapical filament short, about even with tip of unguis (Fig. 273).

Metaleg. Coxa with 4 anterior setae and 1 "courte épine" (Fig. 274); trochanter with 4 anterior and 1 posterior setae (Fig. 275); femur with 10 anterior and 1 posterior setae, outer cup sensillum, 2 setulae, 1 anterior "courte épine" and 1 posterior basal oval organ (Fig.



Figs 227–237. *Dicyrtoma (Calvatomina) microdentata* sp.n.—227. Left eyepatch.—228. Foreclaw.—229. Metaclaw.—230. Colophore, lateral view.—231. Corpus of retinaculum.—232. Manubrium, lateral view.—233. Dental setae E_1 – E_3 .—234. Mucro.—235. Anal papilla, female.—236. Female subanal appendage.—237. Parafurcular setae.



Figs 239–256. *Dicyrtoma (Calvatomina) longidigita* sp.n.—239. Right eyepatch.—240. Antennal segment I.—241. Outer maxillary lobe.—242. Facial setae.—243. Foretibiotsarsus, anterior surface.—244. Foretibiotsarsus, posterior surface.—245. Foreclaw.—246. Mesotibiotsarsus, anterior surface.—247. Mesotibiotsarsus, posterior surface.—248. Mesoclaw.—249. Metatibiotsarsus, anterior surface.—250. Metatibiotsarsus, posterior surface.—251. Metaclaw.—252. Mucro.—253. Anal papilla, female.—254. Female subanal appendage.—255. Parafurcular setae.—256. Dorsal setae of abdomen.

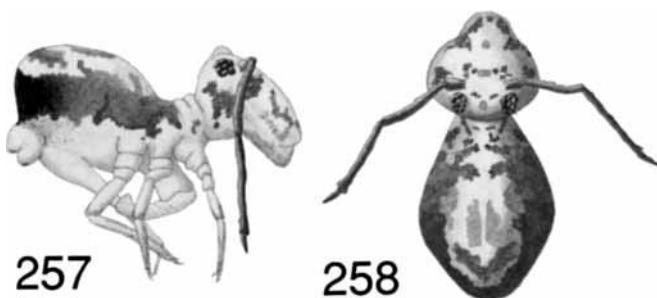
276); tibiotarsus with 5 cup sensilla, 3 “courtes épines” on anterior surface (Fig. 277), 1 “courte épine” on posterior surface (Fig. 278); pretarsus with anterior and posterior setulae; unguis with pseudonychia, tunica, outer tooth,

and 2 inner teeth; unguiculus with 2 corner teeth, subapical filament short, fine, reaching tip of unguis, outer lamella expanded greater than meso-unguiculus (Fig. 279).

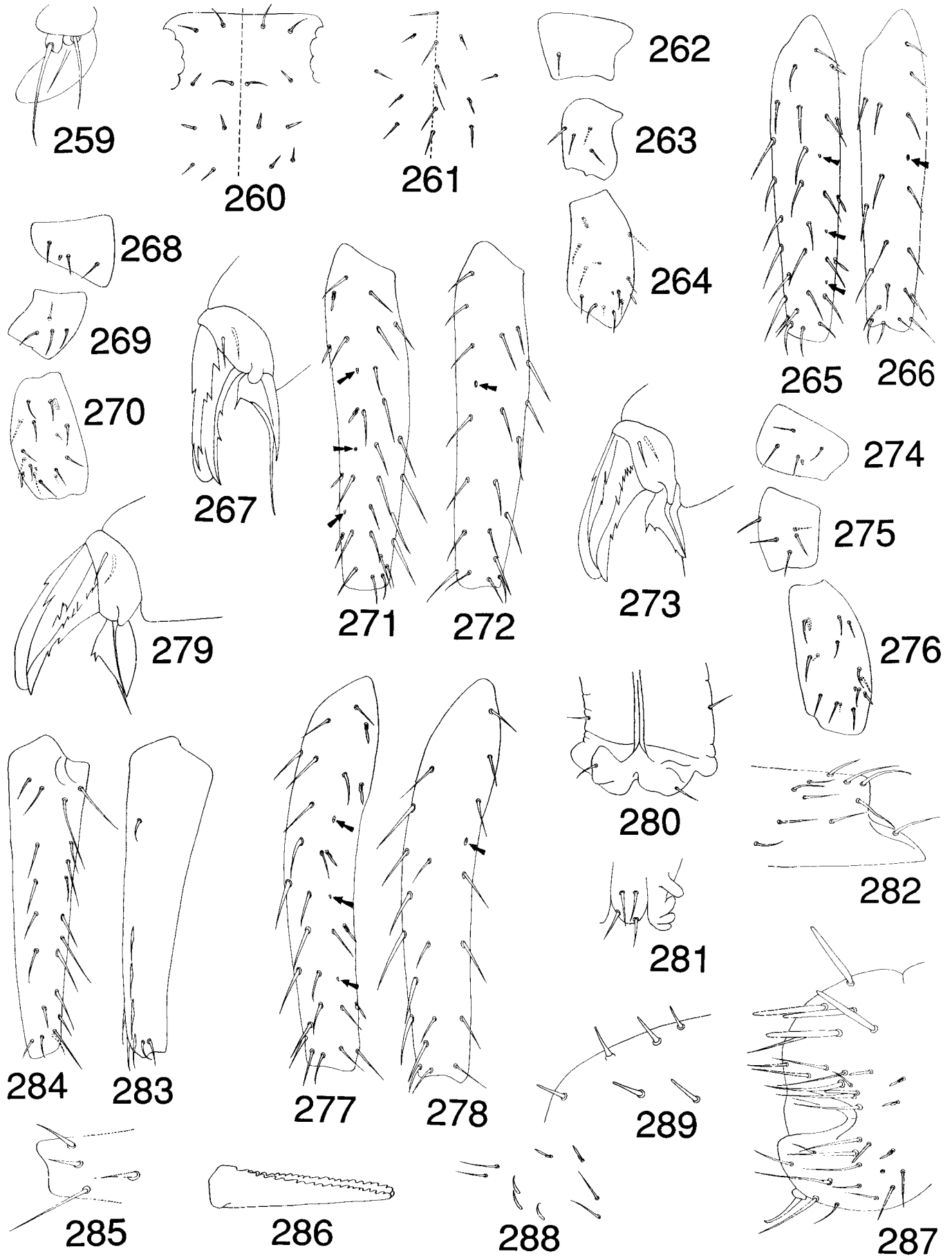
Great abdomen. Collophore with 1 + 1 subapical and 1 + 1 lateral setae, sacs warty (Fig. 280). Corpus of tenaculum with 4 setae, ramus with 3 teeth and basal horn (Fig. 281). Manubrium with 11 + 11 dorsal setae (Fig. 282). Dens with 4, 2, 1, 1 . . . 1 Ve setae (Fig. 283), dorsal E and L setae smooth D_1 – D_3 subequal (Fig. 284), $E_1/E_2 = 1.20$, $E_3/E_2 = 1.25$ (Fig. 285). Mucro with numerous, regularly spaced inner and outer teeth (Fig. 286). Circumanal setae follow the pattern

M	N	A ₀	T	H	G	and	L	M'	N'
+	+	–	–	+	±		+	+	+

(Fig. 287); female subanal appendage heavy, sharp,



Figs 257, 258. *Dicyrtoma (Calvatomina) bellingeri* sp.n.—257. Habitus, lateral view.—258. Habitus, dorsal view. Total length up to 0.85 mm.



Figs 259–289. *Dicyrtoma (Calvatomina) bellingeri* sp.n.—259. Outer maxillary lobe.—260. Dorsal setae of head.—261. Unpaired facial setae.—262. Forecoxa.—263. Foretrochanter.—264. Forefemur.—265. Foretibiotarsus, anterior surface.—266. Foretibiotarsus, posterior surface.—267. Foreclaw.—268. Mesocoxa.—269. Mesotrochanter.—270. Mesofemur.—271. Mesotibiotarsus, anterior surface.—272. Mesotibiotarsus, posterior surface.—273. Mesoclaw.—274. Metacoxa.—275. Metatrochanter.—276. Metafemur.—277. Metatibiotarsus, anterior surface.—278. Metatibiotarsus, posterior surface.—279. Metaclaw.—280. Collophore.—281. Corpus of retinaculum.—282. Manubrium, lateral view.—283. Dens, ventral surface.—284. Dens, dorsal surface.—285. Dental setae E_1-E_3 .—286. Mucro.—287. Anal papilla, female.—288. Parafurcular setae.—289. Posterior abdominal setae.

tapered and curved at apex. Parafurcular setal pattern 3 spine-like and 2 setaceous (Fig. 288). Bothriothrix A, B, C normal, D missing. Body setae fine in thoracic region, becoming spine-like posteriorly (Fig. 289). Length up to 0.85 mm.

Diagnosis. *Dicyrtoma* (*Calvatomina*) *bellingeri* sp.n. is a member of Yosii's (1969) "formosana group". It can easily be separated from those published species on the basis of circumanal setae pattern and claw morphology. Among members of the Hawaiian fauna, *bellingeri* has a unique color pattern that will distinguish it from all others. The circumanal setal pattern is similar to *sylvestra-tilis*, however, the parafurcular setal pattern is 5/0 for that species and 3/2 for *bellingeri*.

Comments on systematics

The tribe Ptenothricini defined by Richards (1968) is composed of genera exhibiting bothriothrix D and two differentiated setae on tibiotarsus P₃. The Hawaiian fauna consists of two subgenera represented by: *Ptenothrix* (*Ptenothrix*) *hawaiiensis* sp.n., *Ptenothrix* (*Papirioides*) *kauaiensis* sp.n., *serrata* sp.n. and *dubia*. Besides the characteristics cited above, Richards (1968) used the presence or absence of subannulation of antennal segments III and IV in his diagnosis. Betsch (1980) discounted this feature. He found that subannulation appeared in stored specimens of *Ptenothrix*, *Dicyrtoma* and *Dicyrtomina*.

Richards (1968) separated *Ptenothrix* and *Papirioides* from *Bothriovulsus* sp. by the presence of bothriothrix A. This appears to be a significant characteristic for division of *Ptenothrix* from *Bothriovulsus*. More recently Betsch

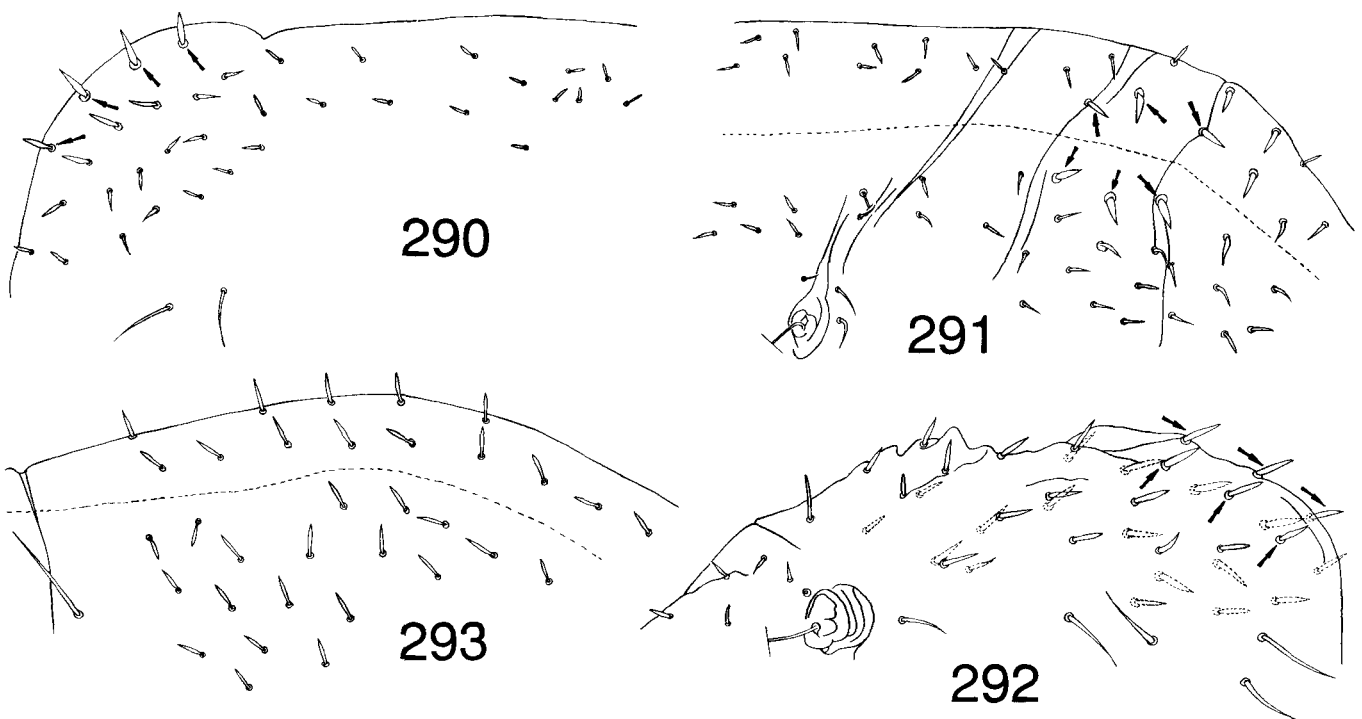
& Weiner (1987) have presented differences between number, shape and pattern of dorsal setae found on the great abdomen which clearly separate *Ptenothrix* and *Bothriovulsus*.

During this study, differences between *Ptenothrix* spp. and *Papirioides* spp. appeared so slight that at the suggestion of Betsch (*in litt.*), *Papirioides* was reduced to a subgenus of *Ptenothrix*. *Ptenothrix* (*Ptenothrix*) *hawaiiensis* sp.n. exhibited the characteristic pattern of 1, 1 blunt, unpaired, median facial setae. This has been suggested as indicative of Holotropical *Ptenothrix* spp. (Yosii 1969; Betsch 1980) and used by Christiansen & Bellingner (1981) for North American identification of the genus.

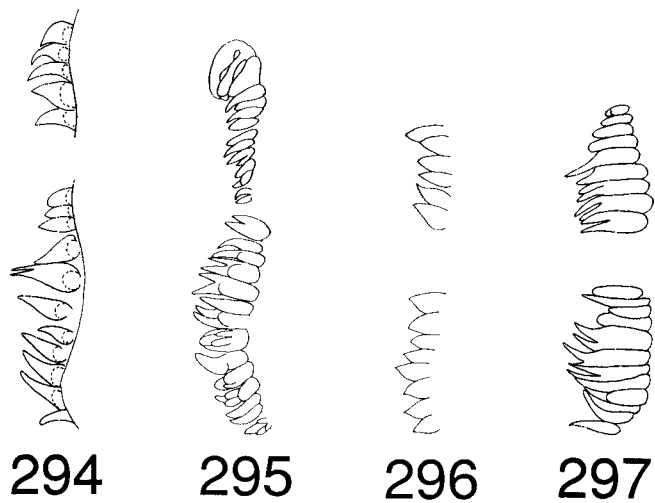
However, contrary to Christiansen and Bellingner, Snider (1985a, b) has shown that two species described from the southeastern United States had facial setal patterns composed of seta-like elements in the arrangement of: 1, 1, 1, 2, 1, 1, 1, 3 for *Ptenothrix* (*Ptenothrix*) *renateae* (Snider) and 1, 1, 1, 1, 1, 1, 3, 4 for *Ptenothrix* (*Ptenothrix*) *castanea* (Snider). Likewise, *Ptenothrix* (*Ptenothrix*) *vittata* (Folsom) from North America and Japan has 1, 1, 1, 2, 1, 1, 1, 3 setae similar to *renateae*.

Among the Hawaiian species *Ptenothrix* (*Papirioides*) *kauaiensis* sp.n. had facial setae in the pattern: 1, 1, 2, 2, 1, 1, 2, 3 with the first two setae blunt, similar to *P. hawaiiensis*; while *Ptenothrix* (*Papirioides*) *serrata* had the pattern: 1, 1, 1, 2, 1, 1, 1, 2 with all setae similar. Unless more new convincing morphological characteristics are found, the presence or absence of blunt, unpaired facial setae becomes doubtful for absolute generic separation.

The relationship of *Papirioides* to *Ptenothrix* is very close. They share almost all morphological features. This problem was recognized by Stach (1965) and Richards (1968). However, the abdominal dorsal posterior pro-



Figs 290–293. Comparison of *Ptenothrix* (*Papirioides*) spp. with abdominal protuberances and *Ptenothrix* (*Ptenothrix*) *hawaiiensis* sp.n.—290. *Ptenothrix* (*Papirioides*) *dubia*, abdominal protuberance.—291. *Ptenothrix* (*Papirioides*) *serrata*, abdominal protuberance, dorsal view, collapsed.—292. *Ptenothrix* (*Papirioides*) *kauaiensis*, abdominal protuberance.—293. *Ptenothrix* (*Papirioides*) *hawaiiensis*, dorsal view of posterior abdomen. Arrows indicate setae associated with abdominal protuberance.



Figs 294–297. Comparison of female upper and lower anal valve glands found among Hawaiian *Ptenothrix* (*Papiroides*) spp. and *Ptenothrix* (*Ptenothrix*) *hawaiiensis* sp.n.—294. *Ptenothrix* (*Papiroides*) *dubia*, upper and lower valve glands of female.—295. *Ptenothrix* (*Papiroides*) *kauaiensis*, upper and lower glands.—296. *Ptenothrix* (*Papiroides*) *serrata*, upper and lower glands.—297. *Ptenothrix* (*Ptenothrix*) *hawaiiensis*, upper and lower glands.

tubercle seems to make separation of the two subgenera possible. Even though both *P. (Papiroides) kauaiensis* and *serrata* share absence of anal seta G with the “*ciliata*” group of *Ptenothrix* (Yosii & Lee, 1963), it continues to make sense to use subgeneric designations.

Within the Dicyrtomini there exists a similar situation where a “group” or subgenus, depending on interpretation, exhibits an abdominal protuberance similar to the condition found in *Ptenothrix (Papiroides)* spp. Of the three reported species in the “*Pseudodicyrtomina* group”, *Dicyrtoma (Calvatomina) bombayensis* Yosii (1966), *Dicyrtoma (Calvatomina) trukana* (Uchida), and *Dicyrtoma (Calvatomina) verrucosa* (Handschin), all appear to have spine-like setae associated with the protuberance in a like manner to *P. (Papiroides) dubia*.

Comparison of *kauaiensis* and *serrata* with *P. (Papiroides) dubia* (Fig. 290) shows that both (Figs 291, 292) exhibit a pattern of spine-like setae on the posterior of the great abdomen in the location of the protuberance. This feature is lacking in *P. (Ptenothrix) hawaiiensis* (Fig. 293). Recently, Betsch (*in litt.*) has suggested that the anal glands of female *Ptenothrix* spp. and *Papiroides* spp. might be useful for subgeneric or even generic separation (Delamare & Massoud 1963; Arle 1976; Soto-Adames 1988). However, comparison of these glands showed that *P. (Papiroides) dubia* (Fig. 294), *kauaiensis* (Fig. 295)

and *serrata* (Fig. 296) are extremely variable and easily intergrade with *Ptenothrix hawaiiensis* (Fig. 297).

It seems logical, until more species are described, that *Papiroides* should be positioned as a subgenus of *Ptenothrix*. In addition, here *Dicyrtoma* has been applied to members of the tribe Dicyrtomini as the generic name. Thus *Dicyrtomina*, *Gibberathrix* and *Calvatomina* become subgeneric designations. To separate them as genera based on tunica inflated or not, and development of the pseudonychia, seems questionable at best.

Zoogeographic considerations

World-wide *Ptenothrix sensu stricto* is represented by 58 published species. Of these, 19 may be classified as Holotropical (Yosii 1969; Betsch 1980). Yosii (1969) suggested that we could recognize *Ptenothrix* from the tropics by the presence of two blunt, unpaired facial setae and a blunt anal seta A₀. *Ptenothrix (Ptenothrix) hawaiiensis* fits into this category. However, we should be careful in generalizing from these characteristics. Betsch (1980) saw the possibility of splitting the Holarctic and Holotropical species into distinct genera. Table VI appears to support, at least partially, this concept with reservations about *Ptenothrix (Ptenothrix) atra*, *marmorata*, and *vittata*.

The distribution of *P. atra* is Holarctic with a southern range reaching Costa Rica (Denis 1931, 1933). This species has both seta-like unpaired facial and A₀ anal setae. Likewise, *P. marmorata* is Nearctic and exhibits two unpaired, blunt facial setae, while A₀ is seta-like. Its range is south to Mexico (D.F.) which places it in the Neotropical region (Handschin 1928). In addition, *marmorata* was recorded from Japan (Uchida 1952b, 1954, 1955, 1959). Another species, *P. vittata*, is found in North America (Folsom 1896; Christiansen & Bellinger 1981), Japan (Yosii & Lee 1963), North Vietnam (Stach 1965) and Australia (*fasciata* Womersley 1932, 1939; Yosii & Lee 1963). *Ptenothrix vittata* has seta-like unpaired facial setae and a blunt A₀ seta.

It appears that both *marmorata* and *vittata* exhibit characteristics of “groups” found in the Holarctic and Holotropical realms. Further collections must be made or examined from the tropics before separation of groups can be made with absolute confidence.

In the diagnosis presented here, *P. hawaiiensis* is placed close to *ciliophora* and *saxatilis* based on morphology of facial, labral and anal valve setae. However, both the latter species are endemic to Korea and do not

Table VI. *Ptenothrix (Ptenothrix) spp. listed by region of the Holotropical realm. Note that A₀b = anal seta A₀ is blunt, A₀S = setaceous and B = 2 blunt, unpaired facial setae, S = facial setae sharp, seta-like*

Neotropical	Oriental	Holotropical	
		Australian	Ethiopian
<i>argentina</i> A ₀ b,B	<i>fiscellata</i> ?	<i>gracilicornis</i> A ₀ b,B	<i>murphyi</i> A ₀ b,B
<i>atra</i> A ₀ s,S	<i>gibbosa</i> A ₀ b,B	<i>hawaiiensis</i> A ₀ b,B	<i>violaceopus</i> A ₀ b,B
<i>borincana</i> A ₀ b,B	<i>himalayensis</i> A ₀ b,B	<i>vittata</i> A ₀ b,S	<i>violacea</i> ?
<i>brasiliensis</i> A ₀ b,B	<i>keralai</i> A ₀ b,B		
<i>dominicana</i> A ₀ b,B	<i>palawanensis</i> A ₀ b,B		
<i>marmorata</i> A ₀ s,B	<i>pulchellus</i> ?		
<i>utinagae</i> A ₀ b,B			

Table VII. Distribution by region of *Ptenothrix* (Papirioides) spp.

Eastern Palearctic	Regions within realms	
	Oriental	Australian
<i>aequituberculata</i>	<i>jacobsoni</i>	<i>dubia</i>
<i>jacobsoni</i>		<i>kauaiensis</i>
<i>mirabilis</i>		<i>serrata</i>
<i>uenoi</i>		

have only 2 blunt, unpaired facial setae. It is also suggested that *P. gracillicornis* is close to *hawaiiensis*. If *vittata* is excluded as only recently being transported to the Australian region, then the closest regionally endemic allied species to *hawaiiensis* becomes *gracillicornis*.

The species *jacobsoni* and *uenoi* are both Palearctic in origin (Table VII). The abdominal protuberance is pronounced, unlike the low structure seen on *aequituberculata* and *dubia*. The heavy, unpaired facial setae are similar in position to those found in *Ptenothrix* spp. However, they are not blunt and of uniform diameter as those seen in species like *P. utingae*, *gracillicornis*, or *murphyi*. The unpaired facial setae of *Papirioides* spp. taper in at least the last 1/8 of their length to a point, giving a gladiform shape. All species, so far, exhibit this shape. The Pacific species unpaired facial setal patterns are presented in Table VIII.

From the known distributions, the origins of *Papirioides* would seem to be eastern Palearctic with dispersion through the Oriental region to the Australian region. Of the three Hawaiian species, *dubia* has the most pro-

Table VIII. *Ptenothrix* (Papirioides) spp. frontal setal patterns of head

Species	Pattern
<i>aequituberculata</i>	1-1-2-2-1-1-1
<i>dubia</i>	1-1-1-1-2-1-1
<i>jacobsoni</i>	1-1-2-1-1-1-1 (3)
<i>kauaiensis</i>	1-1-1-1-1-1-1
<i>mirabilis</i>	Unknown
<i>serrata</i>	1-1-1-2-1-1-1
<i>uenoi</i>	Unknown

nounced abdominal protuberance. It appears that *dubia* and *serrata* are more closely allied to each other than they are to *kauaiensis*. Betsch (1980) reports a species (yet undescribed) close to *dubia* from Madagascar and suggests it may represent an import.

Members of *Dicyrtoma* (*Calvatomina*) spp. are predominant in the Holotropical realm with 12 of 25 species found in the Australian region. It is apparent that *Calvatomina* has successfully established in the Oriental-Australian regions. Today only six species are found in the Holarctic realm (Table IX).

The species *D. (Calvatomina) madestris* sp.n. and *microdentata* sp.n. clearly fall within the "*rufescens* group". They both exhibit spine-like parafurcular setae and have M' reduced to a small seta. They are the first species of the "*rufescens* group" to be recorded from the Australian region and were taken only on Kauai.

The "*formosana* group" species are very similar in many features, especially with 3/2 parafurcular setae. An

Table IX. Known distributions of *Dicyrtoma* (*Calvatomina*) spp.

Holarctic				Holotropical			
Groups (Yosii 1969)	East Palearctic	West Palearctic	Nearectic	Neotropical	Oriental	Australian	Ethiopian
" <i>Pseudodicyrtomina</i> group"							
<i>bombayensis</i>					India		
<i>trukana</i>	Japan						
<i>verrucosa</i>					Philippines		
" <i>bouganvilleae</i> group"							
<i>alacris</i>						Solomon Is.	
<i>bouganvilleae</i>						Solomon Is.	
<i>christianseni</i>				Surinam			
<i>lawrencei</i>						Solomon Is.	
" <i>rufescens</i> group"							
<i>cruciata</i>					India		
<i>madestris</i>						Hawaiian Is.	
<i>microdentata</i>						Hawaiian Is.	
<i>monodi</i>							Angola
<i>opalina</i>			(U.S.A.)				
<i>oryzae</i>							Gambia
<i>pagoda</i>					India, Burma, Sri Lanka		
<i>pallida</i>					India		
<i>pseudorufescens</i>							Sudan
<i>rufescens</i>	Japan	(Europe)		Puerto Rico			
<i>trivandran</i>					India		
<i>yaeyamensis</i>	Okinawa				Java		
" <i>formosana</i> group"							
<i>articulata</i>		Rhodes					
<i>bellingeri</i>						Hawaiian Is.	
<i>brevifibria</i>						Hawaiian Is.	
<i>formosana</i>	Taiwan						
<i>longidigita</i>						Hawaiian Is.	
<i>modesta</i>						Solomon Is.	
<i>nymphascopulas</i>				Puerto Rico			
<i>solomonensis</i>						Solomon Is.	
<i>sylvestratilis</i>						Hawaiian Is.	
<i>tesselata</i>						Hawaiian Is.	

exception is *sylvestrilis* with 5/0. This species resembles *solomonensis* and *modesta* from the Solomon Islands.

The Hawaiian *D. (Calvatomina)* spp. appear to be endemic to specific islands with a possible exception of *brevifibra* which was found on the islands of Hawaii, Oahu and Molokai. The other species are found on the following islands: Kauai-bellingeri, madestris, microdentata, and sylvestrilis; Hawaii-longidigita; and Oahu-tesselata. Collections are either too few or too small to draw strong conclusions about Hawaiian Island distribution.

In view of the Hawaiian species, some speculation about Pacific dicyrtomids and their dispersal can be offered. Richards (1968) has said that the Dicyrtomidae originated before the Cretaceous in the northern hemisphere. He reasoned that today's climate where the plesiomorphic genus *Ptenothrix* occurs was similar to that found during the Cretaceous in the far north. The apomorphic *Dicyrtoma*, *Dicyrtomina* and *Calvatomina* have a nearly cosmopolitan distribution. At the time of his writing, Richards (1968) stated that the Ptenothricini was restricted to the Holarctic and Oriental regions.

If present distribution patterns are examined, it is obvious that the northern Holarctic point of origin is a reasonable theory. Currently there are 58 species of *Ptenothrix* (*Ptenothrix*) published. Of those, 41 can be classified as Holarctic with 5 strictly western Palearctic, 19 eastern Palearctic and 14 Nearctic; 3 species are found in both subregions and 1 of those in the Holotropic realm. There are 17 species found only in the Holotropic realm, with 2 Holarctic species (*atra* and *marmorata*) found in the Neotropical region.

The seven species of *Ptenothrix* (*Papirioides*) are split between three species restricted to the eastern Palearctic, three species in the Australian and one species (*jacobsoni*) found in both the eastern Palearctic and Oriental regions. Oddly, the three Australian region species have low abdominal protuberances as in the Chinese *mirabilis*.

In view of *jacobsoni* being found in both the Palearctic and Oriental regions, the Hawaiian species with similar morphology to *mirabilis* must be more ancient. However, they were probably introduced through the Oriental region to Hawaii via the Malayan, Papuan and Polynesian subregions.

Judging from the distribution of *D. (Calvatomina)* spp., their origins were in the Palearctic with greater dispersal and evolution in the Oriental and Australian regions. However, they are not, so far, found in Australia or New Zealand. If we follow Richards' (1968) reasoning, they represent a subgenus that is phylogenetically between *Ptenothrix* and *D. (Dicyrtomina)* spp.

Thus, zoogeographically we have the ancient Ptenothricini originating and adapting to ever-changing climates, moving slowly southward. Meanwhile the apomorphic Dicyrtomini, equally old, spread more rapidly southward, as well as east and west, to the tropical regions.

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